Design Course

Visual Perception for Communication Designers

Human Factors and Sociotechnical Systems Studios
by
Vivek Kant and Sruthi Sridhar
IDC, IIT Bombay

Source:
https://www.dsource.in/course/visual-perception-communication-designers

Visual Perception for Communication Designers

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2. Nature of Visual Experience
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Source:
https://www.dsource.in/course/visual-perception-communication-designers/1-introduction

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1. Introduction

Why is visual perception useful for designers?

To perceive an image is to participate in a forming process; it is a creative act.
- Gyorgy Kepes

This course is developed for communication design practitioners – graphic designers, photographers, illustrators, and many others who consider themselves a part of this profession. The key idea of this course is to help communication designers understand the foundation of perceptual science and how it is utilized in practice. It consists of a set of explorations done by students of my course related to visual perception. This course is meant to invite students and practitioners to understand the psychological principles behind their work. This scientific understanding will help them to grow reflexively as practitioners.

Psychological science is a broad field of study. Within this vast field, the course covers some topics in perception and serves as a gentle introduction that appeals to the designers' sensibilities. While exploring visual phenomena, key emphasis has been placed on exploring visual illusions. Illusions are phenomena in our everyday lives, with discrepancies between real-world phenomena and how they are perceived. Examples in our everyday lives include a stick that appears bent in a pool of water but is straight. The word illusion arises from the Latin Illudere, meaning "to mock." These "illusory" phenomena mock the trust we place in our senses.

Illusions, in general, are of vital importance to a student of communication design as reproducing them helps in understanding how the outside world of physical phenomena (which the designer can manipulate) is connected to our psychological world of lived experience.

Artists, artisans, and philosophers have addressed illusions and perceptual errors from time immemorial. However, they achieved a significant focus from psychologists in the nineteenth century, when there was a growth in psychological science. During this growth, there was a widespread interest in understanding illusions. One can find the origins of psychology as an experimental science in Germany in the late 1800s. After this time, psychological science grew on both sides of the Atlantic as a scientific subject, searching for the scientific basis of human perceptual experience, among other broader phenomena.

Background of studies in visual experience

During the early 1900s, a new approach to psychology began coalescing in Germany, known as the Gestalt school of thought. Psychology and Philosophy are earlier precedents of the Gestalt school of thought (see Appendix B). Among the proponents of this approach are Kurt Koffka, Max Wertheimer and Wolfgang Kohler. They further trained several students who had an overarching impact on psychological science: Rudolph Arnheim; Kurt Lewin; Wolfgang Metzger; Hans Wallach; Bluma Zeigarnik; Tamara Dembo; Karl Duncker; Maria Ovsiankina; and Kurt Gottschaldt. Amongst these, Rudolph Arnheim significantly impacted the psychology of art and design.

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While the history and background of the Gestalt school are broad, the critical impact on art and design was that practitioners learnt about "laws of visual organization" and a scientific basis for several general principles that supported the insights of practicing artists and designers.

The key idea of "gestalt" was postulated by German scholar Christian Ehrenfels. He observed that there is a necessary "unity" in the way we perceive. For example, when we listen to music, we perceive a melody, not individual tones. Ehrenfels, in his essay "On Gestalt Qualities," highlights that these melodies, conceived as wholes in relation to their parts, are an essential dimension of perceptual experience.

With the shadow of WWII looming in Europe, many gestalt scholars and other psychologists moved to the USA. During this time, various dimensions of psychology were also growing in the USA. With the growth of the computational era, there was the growth of a new science of the mind (i.e. cognitive science) that derived from an amalgamation of psychology, computer science, neuroscience, philosophy and linguistics. The growth of cognitive science also helped develop the "information processing" metaphor of the mind. In this metaphor, the mind is likened to a processing entity that takes in environmental stimuli and processes them to present experiential meaning. Researchers working under the information processing paradigm also seriously considered the key ideas and principles of gestalt psychology and squarely folded them with the information processing metaphor of the mind. The dominant current approaches to understanding visual perception derive from the information processing approach and gestalt psychology.

Along with Gestalt principles, there are also multiple aspects of human perception that will be helpful for communication designers. These include the relation between size and distance; colours, lightness; brightness and contrast, among many other topics.

In our current course, we explore these various visual phenomena, illusions and general topics related to visual perception. These various explorations enable designers to obtain an intuitive understanding of visual phenomena. The following section explores the foundations of visual perception and builds the groundwork for the various explorations in the subsequent sections.

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2. Nature of Visual Experience

2.1 What are visual sensation and perception?

2.2 The Perceptual Process

2.3 Elements and Organization of Perception

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https://www.dsource.in/course/visual-perception-communication-designers/2-nature-visual-experience/21-what-are-visual

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2.1 What are visual sensation and perception?

Imagine sipping a cool masala-cola made by an Indian soft drink brand Thumbs-Up. Can you recognize the brand by seeing the colors and shapes of the logo? How does the drink feel on your tongue? Do you hear the fizziness popping from the drink? The sensation is how information from the outside world enters our brains. During the process of sensation, specific receptors in the sense organs are activated, which enables various forms of external stimuli to be converted into neural signals in the brain. Transduction is the process that converts outside stimuli such as light, sound, smell, touch, and taste into neural activity.

Perception is the process of interpreting and organizing sensations experienced by an individual in a meaningful fashion. For example, if two people are looking at a cloud in the sky, one might think it looks like a dog, while the other might think it looks like a horse. They are both looking at the same cloud but perceive it differently.

Thus, the central point is that perception never occurs singularly, or it can never occur using only a part of the information required. For example, we do not simply perceive color and other entities and dimensions individually. In almost all cases, we recognize them as part of objects, environments and events. Therefore, the focus is on understanding how these dimensions of color, size, distance and depth appear together in a unified experiential whole. However, it is also helpful to comprehend how these various dimensions come together as corroborative and supportive aspects. Thus, designers explore these various dimensions in terms of visual phenomena.

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2.2 The Perceptual Process

The perceptual process, deriving from the information processing metaphor, is a sequence of steps that lead from the stimulus in the environment to an individual's action in response to a stimulus (e.g. masala-cola). This perceptual process is divided into four categories: Stimulus, Electricity, Experience & Action, and Knowledge. Stimulus is what we pay attention to and what is in our surroundings. The stimulus stimulates our receptors, sending an electrical signal to the brain (electricity). This electrical signal is then perceived, recognized, and reacted to (Experience and Action).

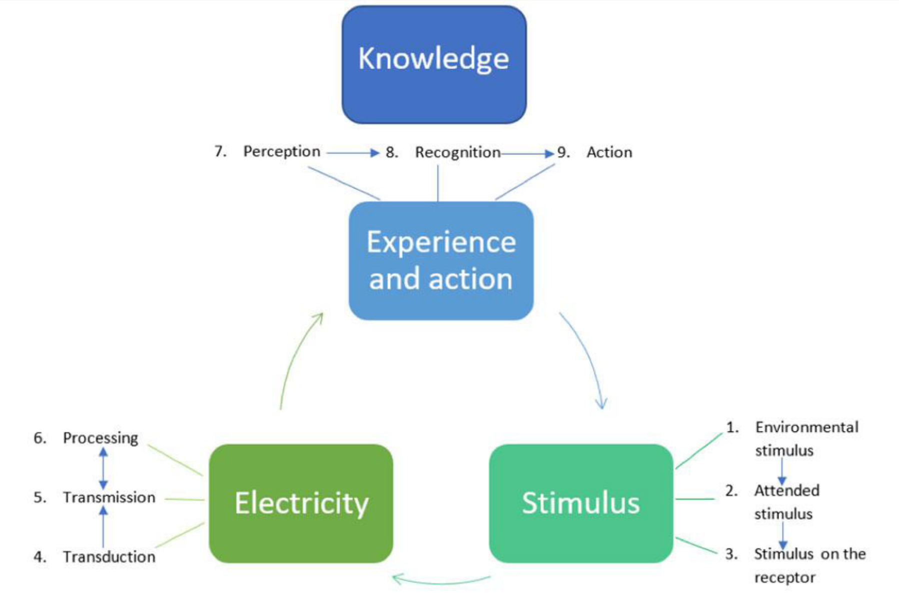

Figure 2.2.a
Source: Sruthi Sridhar. Recreated from Goldstein, 2010

Environmental stimulus is everything in the outside world that we can potentially perceive. This can refer to the multiple sensations, such as sipping the masala-cola, in our earlier example or even in other everyday circumstances. For example, if we are stuck in traffic, there are multiple stimuli one can perceive. It can be other vehicles on the road, the road itself, hoardings on the roadside, street signs etc. However, it is impossible to focus on everything at once. Therefore, when stuck in traffic, if we decide to look at a bright advertisement, the hoarding will have all our attention, thus becoming the attended stimulus. However, once the traffic starts moving, the cars in the surrounding might become the attended stimulus due to the shift in attention — the attended stimulus changes as our attention shifts from place to place.

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When we start focusing on the advertisement, we start looking at it directly, which creates an image of the ad and its surrounding on the receptors of our retina. This is a crucial step as the ad's image (stimulus) is transformed into another form - light impulses on our retina.

The next step in the perceptual process is transforming these light impulses into electricity. Converting the light stimulus (font of the advertisement) into an electrical stimulus is known as transduction. Next, following the font's image transformation into electrical impulses in our receptors, these signals stimulate neurons, activating additional neurons. These signals eventually leave the eye and are transmitted to the brain. The transmission step is critical as no perception occurs if the impulses do not reach the brain. These electrical signals are then processed through a network of neurons in our brains, leading to our perception of the image.

This setup can be likened to a communication system. The image below compares the neurological system and cell phone signal transmission.

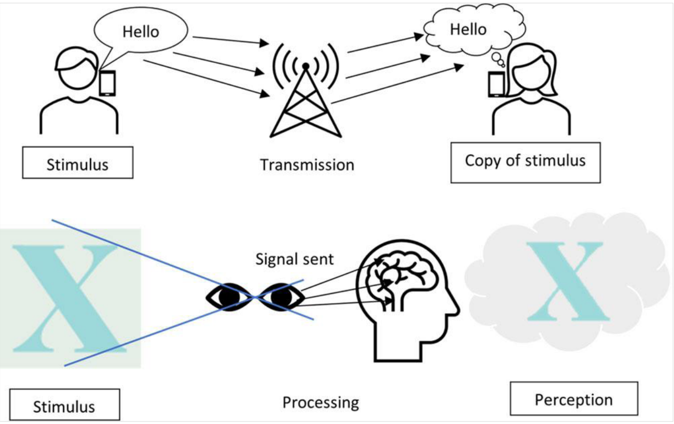

Figure 2.2.b
Source: Sruthi Sridhar. Recreated from Goldstein, 2010

The image on top shows the transmission of an electrical signal meaning "hello" between two cell phones. The signal received by the cell phone is identical to the signal sent. Cell phones are designed to send a replica of the original signal. However, there are distinctions between information transmission between cell phones and information transmission in the nervous system. The nervous system (eye) sends electrical signals representing the letter "x" to the brain. Because the nervous system processes these electrical signals, the signal responsible for letter perception differs from the initial signal provided by the eye. The information that reaches the brain is changed in the nervous system so that, while it represents the original stimulus, it is usually considered different from the original signal.

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The third stage of the perceptual process is where the information is processed into things, and we become "aware." This entails perceiving or recognizing an object or acting on the object in the environment. As mentioned before, perception is the conscious experience of sensations. Recognition is the ability to provide meaning to an object by categorizing it, such as the "letter x." Finally, the action includes motor actions such as moving the head or eyes or locomotion through the surroundings. For example, in the case of advertisement, moving our eyes and head to read the subsequent letters to know what comes next.

In addition, past knowledge plays a role in our everyday understanding. Because knowledge can influence several steps in the perceptual process, it is positioned above the circle. Information that a person brings to a situation can include items learned years ago, such as learning the alphabet as a child or knowledge gained through recent occurrences can all impact perceptual processes.

The difference between bottom-up and top-down processing can better explain the role of previous knowledge in the perceptual process. Bottom-up processing is processing information based on incoming data. Bottom-up processing is data-driven, where the incoming data becomes the starting point and takes place in real time. In the example of the masala cola, you would look at the color (dark), fizziness, presence of masala, and smell and taste of the drink to recognize it as a tasty masala cola.

In contrast to the above, top-down processing refers to processing based on previous knowledge, where the information coming in is interpreted using contextual clues with the help of prior experience and expectations. For example, in our earlier case of cola, the shape and colors of our logo from our past experiences in various advertisements help us recall the brand. Designers often emphasize brand recall in the branding of various products.

Let us take another example; let's look at the picture below. One might identify the middle symbol as a "13" by implementing bottom-up processing. It would work as you have previously learnt what a "13" is and what it looks like when typed on a paper. Therefore, if no context is provided, one would recognize the markings as the numerical "13" after sending the stimuli to your visual context and analyzing the stimuli.

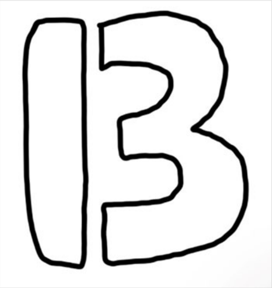

Figure 2.2.c
Source: Sruthi Sridhar

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The outcome of top-down processing might be different. Say there were two markings between an "A" and a "C." You will interpret it as "B" when you see the two markings. Based on your understanding of the other information provided, you assume the marking is an alphabet instead of a numerical one. But due to top-down processing, your original interpretation of the markings differed from the numerical "13."

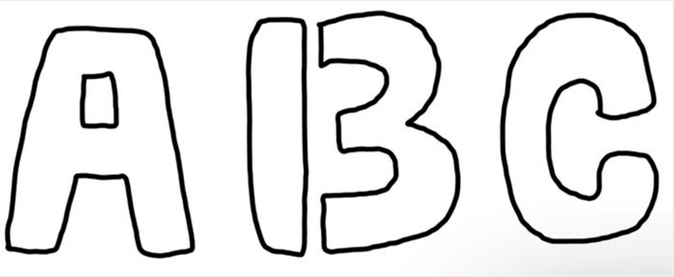

Figure 2.2.d
Source: Sruthi Sridhar

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2.3 Elements and Organization of Perception

Perception is the process of interpreting and organizing the sensations that one is experiencing at any particular time in a meaningful way. As unique as each person's perception is, there are many commonalities in how people see the world. As a result, there are times when distinct individuals appear to experience stimuli in nearly the same way. An attempt to make these underlying principles clear was in the form of postulating certain underlying principles that describes our perception of the world. The Gestalt principles of organization are one such attempt to explain how sensory phenomena become organized into meaningful wholes.

Gestalt is a field whose forces are organized in a self-contained, balanced whole. - Rudolf Arnheim.

In a gestalt, components interact to such an extent that changes in the whole influence the nature of the parts and vice versa - Rudolf Arnheim.

The gathering of components in an image to generate larger objects is known as perceptual organization. Here are six of the Gestalt psychologists' proposed laws of an organization to describe how perceptual grouping like this occurs.

Pragnanz: Pragnanz is a German word that approximately translates to "good figure" or, in some cases, "simple figure." The primary law of Gestalt psychology is the principle of Pragnanz, often known as the law of good figure or the law of simplicity: every stimulus pattern is viewed in a way to achieve a structure that is as simple as possible. For example, the image on the left will be perceived as five circles instead of nine individual shapes (the image on the right). Logo designers often use this principle to devise their logos. The figure simulates the emblem of the Olympic Games. The five rings as viewed as rings and constitute one whole set of rings due to the simplicity of perceiving them as closed rings rather than disjointed figures.

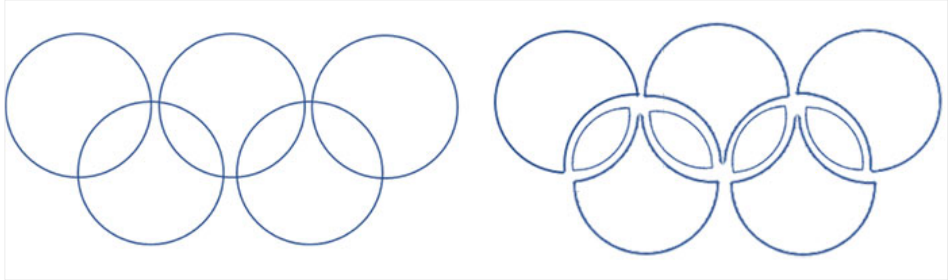

Figure 2.3.a
Source: Sruthi Sridhar. Recreated from Goldstein, 2010

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Similarity: The tendency to regard objects that appear the same as belonging to one group is known as a similarity. When members of a sports team wear identical uniforms, spectators can perceive them as a single unit, even if they are dispersed all over a field or court. For example, in the image on the left, the circles can be perceived as being in both horizontal rows and vertical columns, whereas in the image on the right, you can only perceive them as being in vertical columns. Now imagine that as a designer, you have to create a brand identity for a client. One of the key ideas in the branding activity will be to create a common theme that will run through the styling of the various merchandise. One can achieve this by using common colors, shades and a design language based on the principle of similarity.

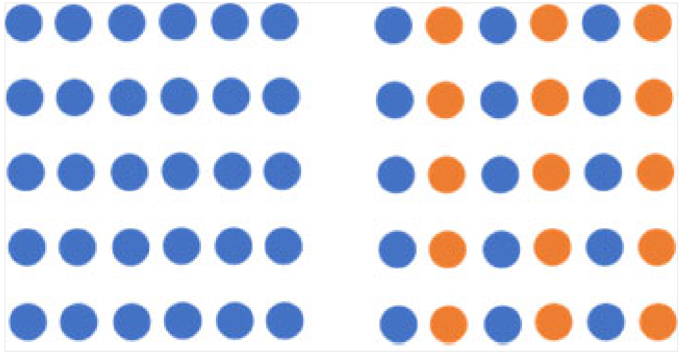

Figure 2.3.b
Source: Sruthi Sridhar. Recreated from Ciccarelli and White, 2018

Continuity: Points that link to form straight or smoothly curving lines are regarded as belonging together, and the lines are viewed in such a way that they follow the smoothest course. For example, we are considerably more likely to interpret the figure on the left as being made up of two lines, 1 to 2 and 3 to 4, than as a figure made up of lines 1 to 4 and 3 to 2 or 1 to 3 and 2 to 4, because of continuity. An example of continuity is the company Volkswagen's logo. This logo has a distinct V and W with minimal spacing between the two, which is recognized by viewers demonstrating the idea of continuity, as in the first figure below.

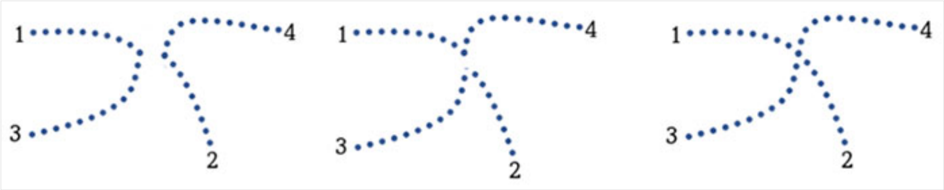

Figure 2.3.c
Source: Sruthi Sridhar. Recreated from Ciccarelli and White, 2018

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Closure: The tendency to finish incomplete figures is known as closure. We recognize these figures as a circle and a square despite the broken lines. This principle is also used in many logos, such as the famous logo of IBM. This principle is also explored in multiple ways and mixed with other principles to produce a final result.

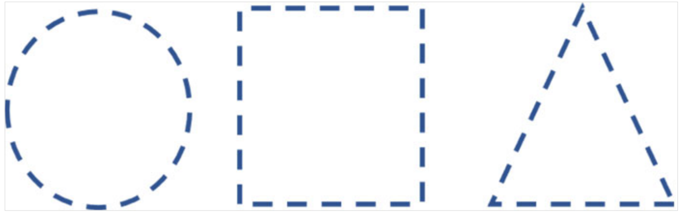

Figure 2.3.d
Source: Sruthi Sridhar. Recreated from Ciccarelli and White, 2018

Proximity: Proximity refers to the tendency to see physically or geographically close objects as belonging to the same group. For example, the dots on the left can be interpreted as horizontal or vertical rows; neither arrangement is dominant. However, shifting the distance between particular dots, like in the other two examples, causes the dots to appear as vertical columns (middle) or horizontal rows (right).

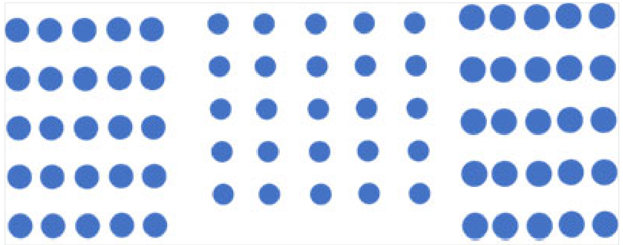

Figure 2.3.e
Source: Sruthi Sridhar. Recreated from Goldstein, 2010

Common Region: Elements in the same spatial region appear to be grouped. For example, even though the law of similarity would suggest that we see two groups, sun and moon. However, the coloured backgrounds create a common region, and there is a tendency to see three distinct groupings.

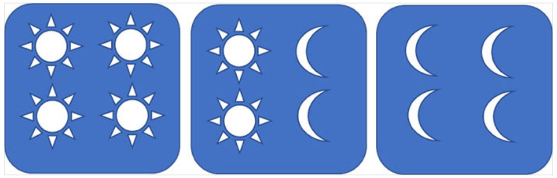

Figure 2.3.f
Source: Sruthi Sridhar. Recreated from Ciccarelli and White, 2018

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Uniform Connectedness: A connected region of visual elements, such as luminance, colour, texture, or motion, is viewed as a single unit. For example, the connected circles in the image below are regarded as clustered together. This principle often plays around with positive and negative space in logos.

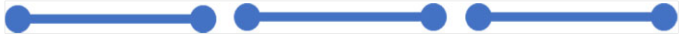

Figure 2.3.g
Source: Sruthi Sridhar. Recreated from Goldstein, 2010

The key idea presented by these rules of organization is that designers can use them to create their own new creations while using them optimally in a creative and playful mode. While Gestalt laws of perceptual organization lie at the foundation of visual perception and are also known by designers, several elements of visual perception are essential for our perceptual experience. They range from figure-ground segregation to the perception of size, distance and depth. These are explored further in the following sections with detailed examples from communication design.

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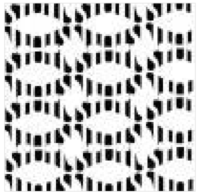
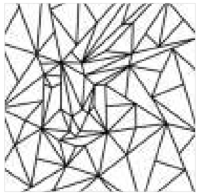
3. Figure-ground Segregation

3.1 Perceptual Segregation

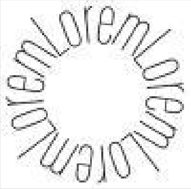


3.2 Figure-Ground Reversal

3.3 Camouflage



3.4 Embedded Figures



3.5 Illusory Contours

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3.1 Perceptual Segregation

As a communication designer, you are often involved in creating logos, where you create an interplay of elements in the "front" instead of in the "back." The elements in the front are known as the figure as they constitute an entity that you often identify. The elements in the back constitute the ground. Figure and ground appear in a variety of contexts in graphic design. Examples include famous logos such as the T (white figure, blue background) in the TATA logo designed by the British agency Wolff Olins.

Photographers often use the concept of positive space (figure) and negative space (ground) to denote this aspect. A very famous demonstration of this figure-ground distinction is obtained in the Japanese style of art called the Notan (light/shadow). Here, the negative space (ground) is sufficiently enclosed; thus, the viewer finds that the meaning changes based on the part that becomes the figure. The graphic symbol depicting the Taoist principles of yin and yang is an excellent example of a shift between light and dark.

Dynamic interaction in the field decides what becomes a unit, what is excluded from it, what is a figure, and what falls back as mere ground. – Wolfgang Kohler

Look at any landscape photograph. You see the shape of things, the mountains and trees and buildings, but not the sky. – Kurt Koffka

Perceptual segregation, or separating one item from another, was also a topic of concern to Gestalt psychologists. The problem of figure-ground segregation refers to the challenge of what causes perceptual segregation. When we view a distinct object, we usually see it as a figure that stands out against its background, referred to as the ground. For example, you might see a lamp on your bedside table as the figure and the tabletop as the ground. Or you may recognize the logo of our favourite masala cola on a billboard from afar. The logo (figure) stands out from the background. The critical challenge in this course is not only to recognize that figure-ground segregation occurs but how does it occur? Can designers use these segregation principles to design better?

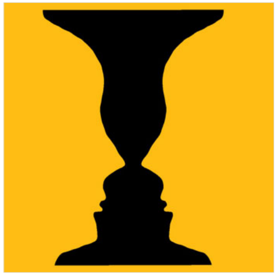

Figure 3.1.a
Source: Sruthi Sridhar. Recreated from Goldstein, 2010 (page 108)

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Properties of Figure-ground Separation

One way to understand the segregation principles is to explore figures like the one below. It was proposed by Danish psychologist Edgar Rubin in 1915. The picture below is called a "bistable figure." It is bistable because you can switch between recognizing the faces and vases in a continually changing fashion. In other words, it can be seen as two yellow faces looking at each other in front of a black background or as a black vase on a yellow background, and this pattern is an example of a reversible figure-ground. There are three essential properties of figure and ground:

1. In contrast to the ground, the figure is more "thing-like" and distinct. As a result, the vase looks like a memorable object when seen as a figure. However, when you see the black area as the ground, it does not appear to be an item and is forgettable.

2. The figure appears to be standing in front of the ground. As a result, the vase seems to be in front of the yellow backdrop, whereas the faces look to be on top of the dark background (black) when seen as a figure.

3. The ground appears to be made of unformed material and extends behind the figure.

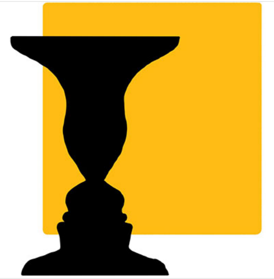

Figure 3.1.b

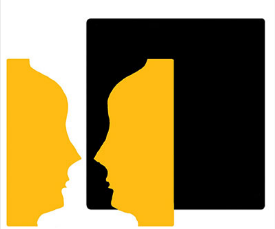

Figure 3.1.c
Source: Sruthi Sridhar. Recreated from Goldstein, 2010 (page 108)

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Figure-ground is fundamentally the visual relationship between the foreground and background of a picture or between the item and the space it occupies (positive negative space in photography terms). The term "figure-ground" literally refers to our capacity to distinguish between objects in our visual field based on contrasts like light and dark or black and white. We notice brightness, especially when contrasted with something dark or monotonous, and an essential, uncomplicated background helps us better understand the person or focal point of the artwork.

For example, look at the images below.

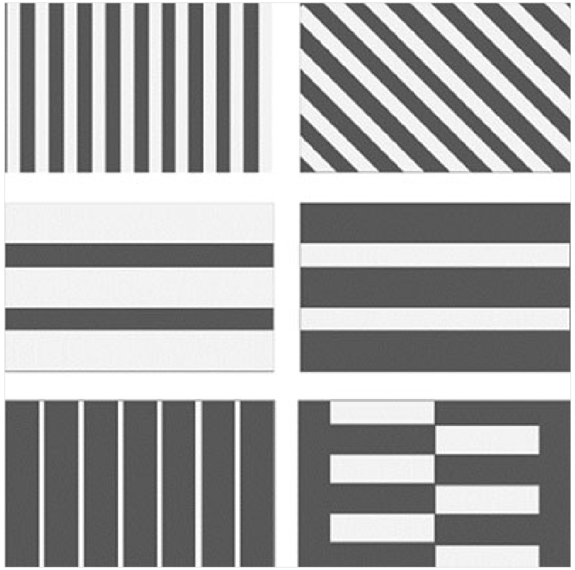

Figure 3.1.d
Source: Hemanth

When the image is made up of stripes that are all the same weight, it is difficult to distinguish between the ground and the figure since no cues are provided. It appears flat. However, when this uniformity of the stripes is broken, one can tell the difference between the figure and background, but the sense remains ambiguous. Some people see black stripes over white, while others see the opposite.

Effective figure-ground relationships occur when the viewer can easily recognize a figure as a unique item distinct from the composition's background—finding a balance between these components that works for your design and messaging is how one should handle figure-ground connections. Designers often work on an exquisite balance of figure-ground segregation when designing logos. The image below shows the possibilities of the interplay of figure and ground from a designer's sketchpad.

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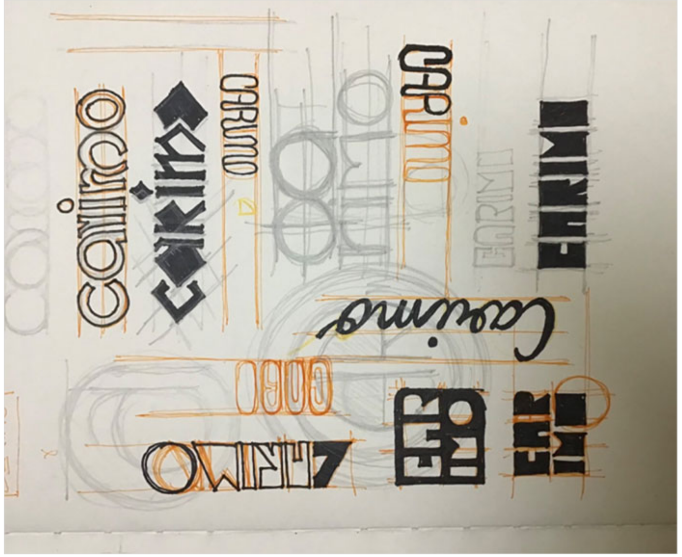

Figure 3.1.e
Source: Nidhin Joseph

How do people distinguish between figure and ground?
Our brain employs various strategies to distinguish between the figure and the ground. Some of them are listed below:

Blur: To show the distance between the viewer and the item, objects in the background may appear fuzzy or hazy, while those in the foreground are frequently more explicit images and more distinct. Photographers add this blurriness by focusing on the subject matter, thus making the figure stand out. In the figure below, the photographer explicitly blurred the background, using a filter on the phone, making the figure stand out.

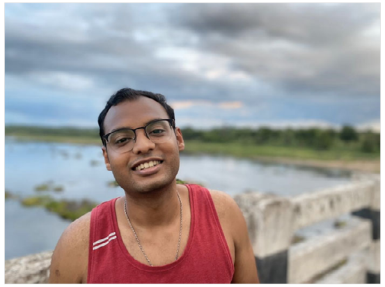

Figure 3.1.f
Source: Vivek Kant

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Separation: Any object that stands out from the surrounding visual features is more likely to be comprehended as a figure than as a background. For example, in the example below, because we are used to seeing faces, we would assume the darker portions to be the face and everything else to be the background. Similarly, because we are well acquainted with the alphabet shapes, we consider the darker areas to be the foreground and the lighter areas to be the background.

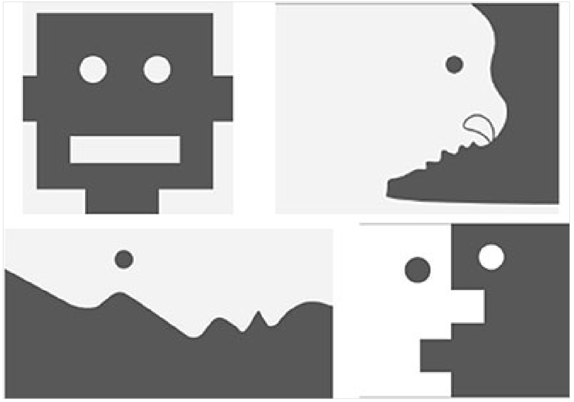

Figure 3.1.g

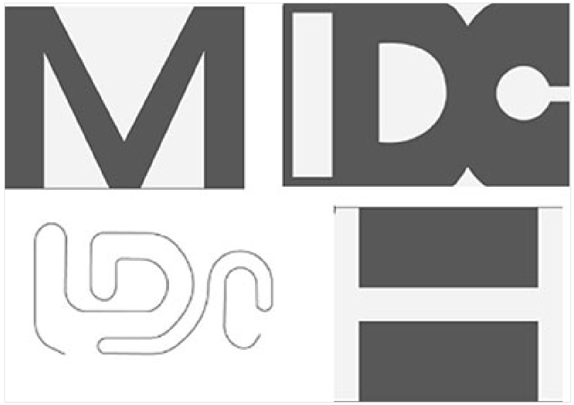

Figure 3.1.h
Source: Hemanth

Contrast: High contrast between design cues can make it easier to tell a figure from its background. In the image below, the letters CARIMO are in high contrast from the background.

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Visual Perception for Communication Designers

Human Factors and Sociotechnical Systems Studios
by
Vivek Kant and Sruthi Sridhar
IDC, IIT Bombay

Source:
https://www.dsource.in/course/visual-perception-communication-designers/3-figure-ground-segregation/31-perceptual

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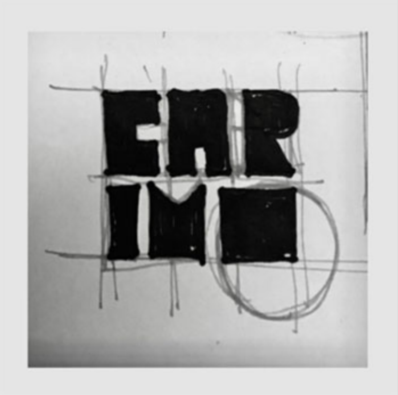

Figure 3.1.i
Source: Nidhin Joseph

Similarly, in the picture below, there is a high contrast between the two elements in the image. Therefore, we perceive the lighter area as a "mountain" and the darker area as the background.

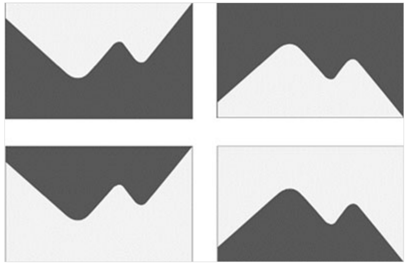

Figure 3.1.j
Source: Hemanth

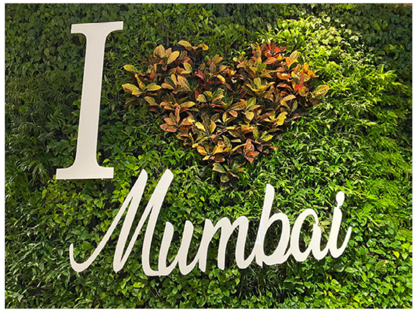

Figure 3.1.k
Source: Vivek Kant

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Size: On a 2D plane, where visual depth relies on deceiving the eye, our brains are built to interpret larger objects as being closer and smaller items as further away. Graphic designers working on the 2D plane will benefit from the idea when designing posters which do not have depth cues. In the above example, the lower-level letters appear further in the distance from the characters in the top line due to the size difference.

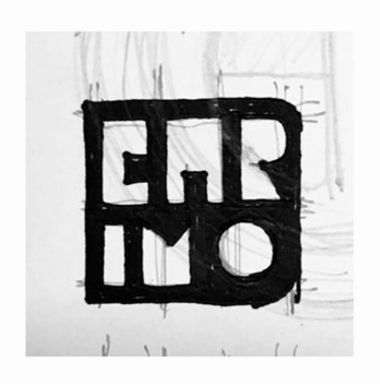

Figure 3.1.l
Source: Nidhin Joseph

Different Types of Figure-ground Relationships

Simple figure-ground: A simple figure-ground interaction is produced when coherent, independent objects are placed next to each other in an area that serves as the surrounding ground. These compositions always have a negative and passive foundation and positive and active figures. Simple figure-ground interactions make figures distinct from the background and easily recognizable.

Figure-ground reversal. Figure-ground reversals occur when the ground becomes the figure while the figure becomes the ground and comes into focus. Shapes that emerge in the gaps between the figure’s components invert these roles. Figure-ground reversals bind and restrict images, while simple figure-ground compositions give the impression that limits are endless. The best example of this is the hidden text illusion.

Ambiguous figure-ground. These types of figure-ground examples exist between the two types mentioned above. When the visual relationships between the composition’s object and space are challenging to discern but completely understandable, ambiguous figure-grounds are produced. Typically, items in this type of figure-ground connection have the same edge or contour. Edgar Rubin’s vase is a well-known illustration of ambiguous figure-ground interactions. In this classic image, two positive black spaces are used to create human facial profiles, while the positive inverse spaces are used to create a vase. The ambiguity of the object and background leaves room for the viewer’s interpretation.

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Along with the ambiguity of the figure and ground, the contours in between also hold significance for typographers. This is often seen in the case of ligatures in typography (e.g., the ligature Æ with a common contour). Another example of the playful use of a contour can be seen when an image shares a common contour - this results in an illusion.

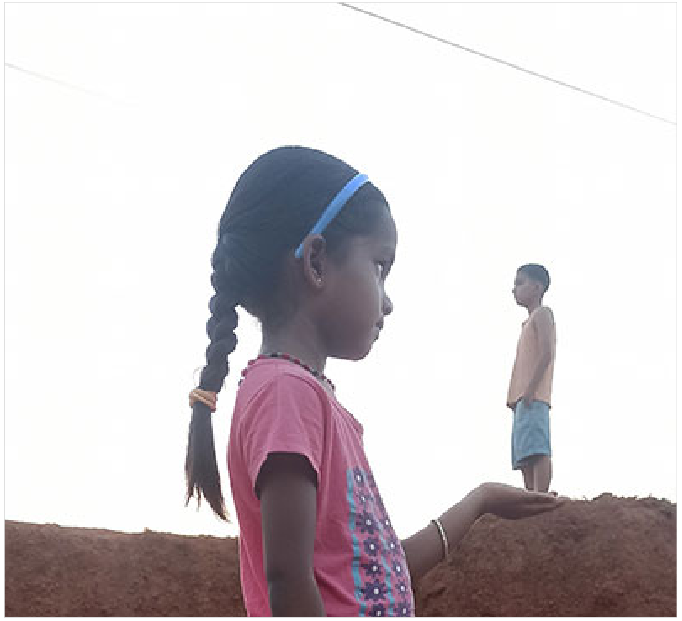

Figure 3.1.m
Source: Shraddha Prabhu

The above issues are explained for figure-ground segregation more generically. It is future explored in terms of two phenomena of figure-ground reversal using typography and camouflage principles developed by artists.

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3.2 Figure-Ground Reversal

Can you see a hidden message in the image below?

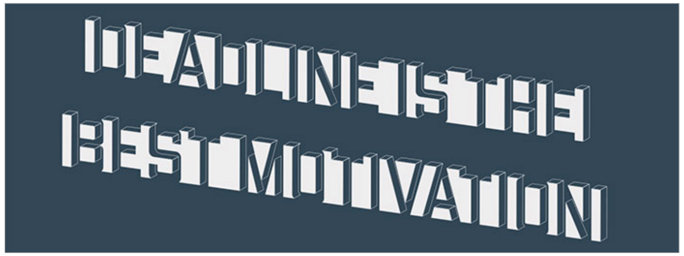

Figure 3.2.a
Source: Amit Patjoshi

Can you see the text "Deadline is the best motivation"? If you cannot, try squinting your eyes to the extent where the picture seems blurred. If it is challenging to squint your eyes, you can also step away from the screen. Alternatively, you can zoom in and out if you are seeing this image digitally. Do you see the hidden text now?

This is a type of figure-ground reversal. On the face of it, the image above most likely appears to be a collection of randomly arranged blocks. It shows a message when you squint your eyes or change the focus of the image to make it blurry.

Why does a blurry image change what you see?

The spatial frequency of the image affects what we see. Spatial frequency is a term that describes the intermittent distributions of light and dark in an image. There are two types of spatial frequency: high and low. High spatial frequencies correspond to features with intricate characteristics, such as sharp edges (Image 1, below). Low spatial frequencies correspond to the feature's overall form as it is low on details (Image 2, below). Image 2, a blurry counterpart of Image 1, can be seen as a result of squinting the eyes. In image 2, the figure and ground are recalculated because we stopped paying attention to the more minor features that characterize the three-dimensional blocks.

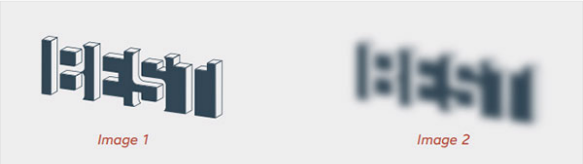

Figure 3.2.b
Source: Amit Patjoshi

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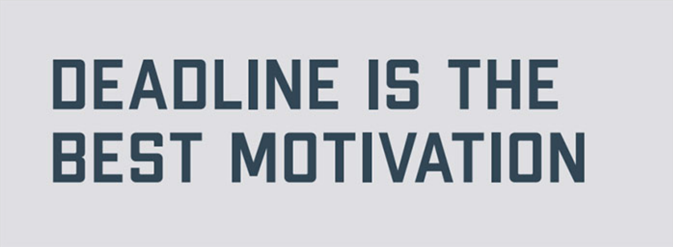
When one squints their eyes, a significant low spatial-pass filtering occurs, causing us to see overall shapes rather than distinct features and edges. As a result, 3D masking cues are eliminated, allowing for a new assessment of what is considered figure and ground.

How to create an adept figure-ground reversal?

The first step is to pick the correct font and the sentence or word to transform. Although one can use any font to achieve the desired illusion, it is crucial to eliminate any visual signals that could help the viewer recognize the true purpose of the final illusion. For this precise reason, letters like "C," "S," "D," etc. must have very little or extremely low curves in the font. After extensive investigation, it was discovered that "Apex Mk3" had similar characteristics and was the ideal typeface for the illusion. Additionally, the font's letter spacing should be identical, and one should manually adjust the tracking to match the letter thickness.

Even though it is feasible to achieve the same illusion with just one word, using a sentence adds a sense of depth and highlights the illusion's impact.

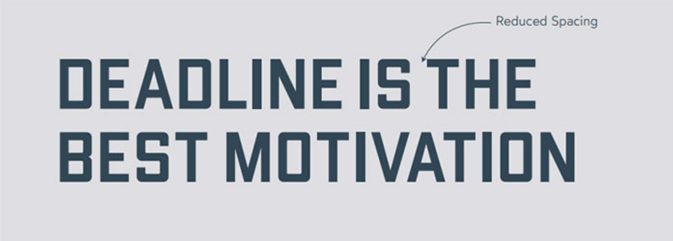


DEADLINE IS THE
BEST MOTIVATION

Figure 3.2.c
Source: Amit Patjoshi

The second step is to adjust the spacing and convert it to an outline. The font spacing was made equal and matched with the letter thickness to decrease visual cues.

One should also minimize the spaces between each word to make recognition simple and the space uniform.



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BEST MOTIVATION

Figure 3.2.d
Source: Amit Patjoshi

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The third step is to create a negative. To make an extrusion, one must first construct the negative of the desired sentence. The extrusion would give the impression that a random assortment of blocks was scattered throughout space and enhance the illusion.

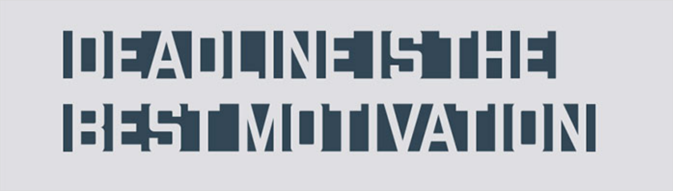

Figure 3.2.e
Source: Amit Patjoshi

The fourth step is to create an extrusion using the negative. It was discovered that additional visual cues, such as shadows and reflection of the curves, diminished the illusion.

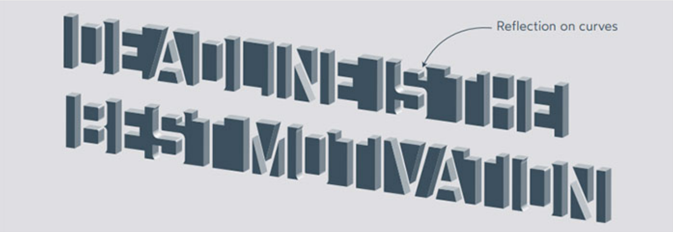

Figure 3.2.f
Source: Amit Patjoshi

An additional step was recommended to combat the problem mentioned in step four. The fifth step is to create a wire mesh of the extrusion. The extrusion was converted into a wire mesh, eliminating the extrusion's light and shade properties.

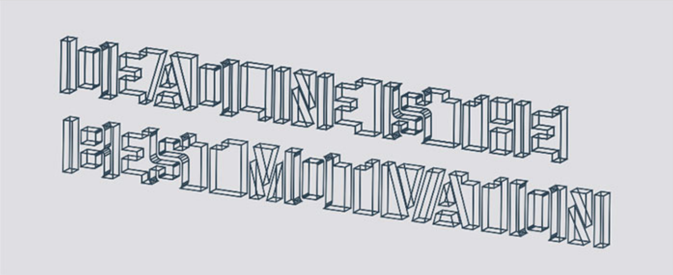

Figure 3.2.g
Source: Amit Patjoshi

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The sixth step is to fill up the figure in the wire mesh. One should combine the wire mesh and the negative to create the desired effect.

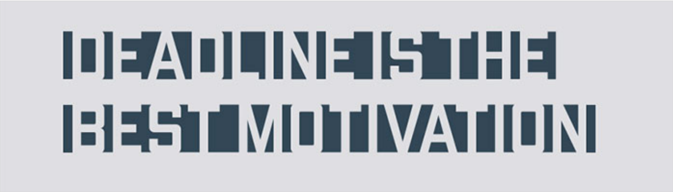

Figure 3.2.h
Source: Amit Patjoshi

However, not all figure-ground reversal needs the viewer to squint their eyes to see the text. For example, it is pretty clear in the picture below that the white is the foreground, and the back is the background. Therefore, one can identify the word CAP without any issues.

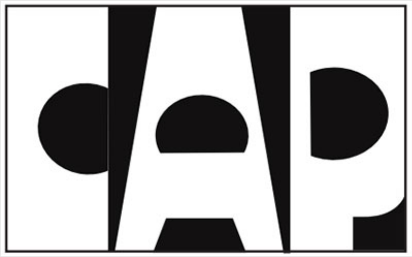

Figure 3.2.i
Source: Stuti Swamiwal

The exploration below is quite compelling. Depending on which part of the picture one looks at, what one considers figure and ground changes.

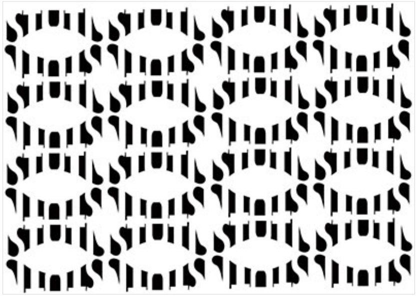

Figure 3.2.j
Source: Stuti Swamiwal

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For example, if you look at the picture below, the black part is considered the ground and the white part is viewed as the figure. Therefore, one can make out the word “STUTI.”

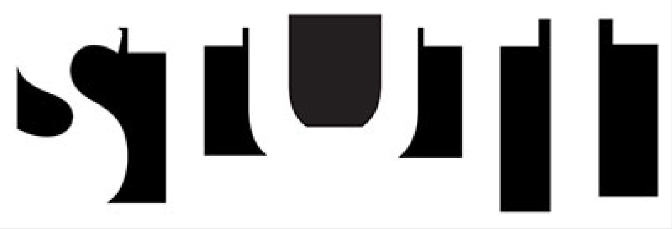

Figure 3.2.k
Source: Stuti Swamiwal

When one adds a conventional figure, the white is considered the figure; however, finding the word STUTI becomes a little bit difficult.

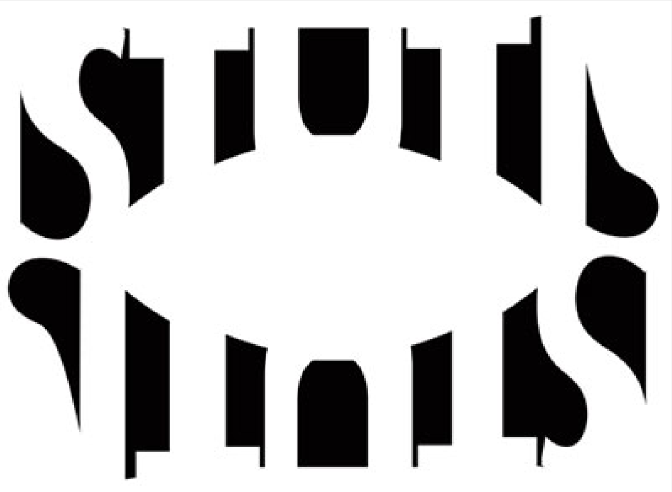

Figure 3.2.l
Source: Stuti Swamiwal

You can find more explorations of the figure-ground reversal in this pdf link.

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3.3 Camouflage

Camouflage occurs when there is inadequate figure-ground segregation, making it difficult to perceive an object against its background. The object is said to be camouflaged if our brain cannot distinguish and recognize it from its surroundings. For instance, in the image below, the figure against the darker background is the light-green caterpillar, making it easy to identify. It is said to be camouflaged when we struggle to achieve this kind of differentiation.

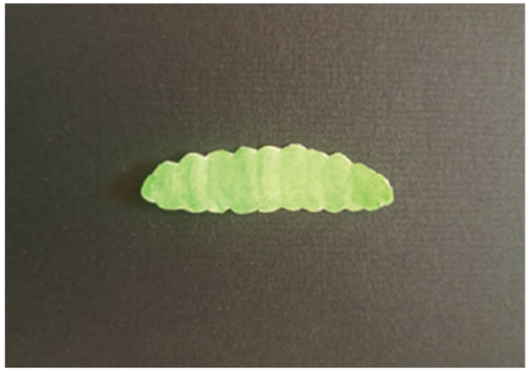

Figure 3.3.a
Source: Shraddha Prabhu

In nature, predators and prey use camouflage to blend in with their environment and prevent being seen. The prey may disguise themselves as tree branches, leaves, grass, or other objects to avoid being attacked. Moreover, military personnel, police, hunters, and nature photographers may have specially made suits to blend into their environment and hide from potential opponents or targets. The suit creates a three-dimensional breakup of the wearer's shape rather than a linear one.

An American artist Abbott Thayer explored camouflage in the natural world of birds and animals in great detail in the late 1800s and early 1900s. In his book "Concealing-Coloration in the Animal Kingdom," with his son Gerald Thayer, many camouflage techniques are discussed. These include countershading, and disruptive coloration, among many others. Some of these are explored in greater detail in this subsection. Camouflage was used extensively in the first world war by painting warships so that one disrupted their figural properties.

Animals employ natural camouflage as one strategy to protect themselves. There are numerous ways to accomplish camouflage. One approach is for the animal to blend in with its surroundings, while another is for it to displace itself as something tedious or hazardous. There are four common types of camouflage: Blending, Countershading, mimicry, and disruption. These four types will be explored using the caterpillar example below.

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Blending: A technique for concealment whereby an object is made to blend in with its surroundings or background so thoroughly that it can no longer be recognized as a separate entity. Caterpillars have restricted mobility and must employ creative ways to protect themselves from predators. The ideal strategy is to blend in with its surroundings, so identifying them is difficult. Therefore, the caterpillars are typically green in colour to blend in with the leaves they consume, making it challenging for their predators to distinguish them from their environment.

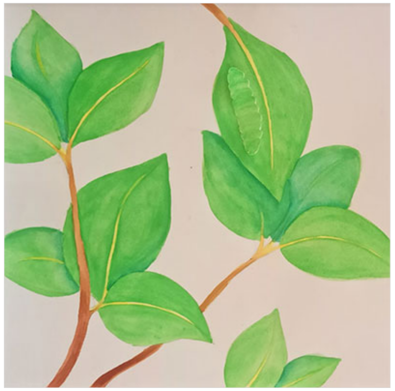

Figure 3.3.b
Source: Shraddha Prabhu

However, there is an issue. When viewed from the side, the upper half of the caterpillar’s body appears lighter than its bottom half, which makes it appear “solid.” This makes it easier for predators to spot as figure-ground segregation is made simpler against “flat” leaves. Therefore, they use countershading to deal with this situation.

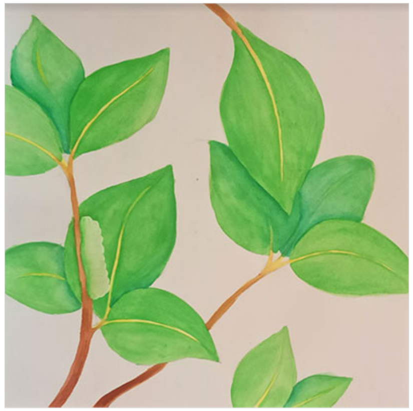

Figure 3.3.c
Source: Shraddha Prabhu

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Countershading: Countershading (also known as obliterative camouflage) involves using different colours on upper and lower surfaces in gradations of tone. In the caterpillar's case, it will start with a pale belly that will change into a darker back.

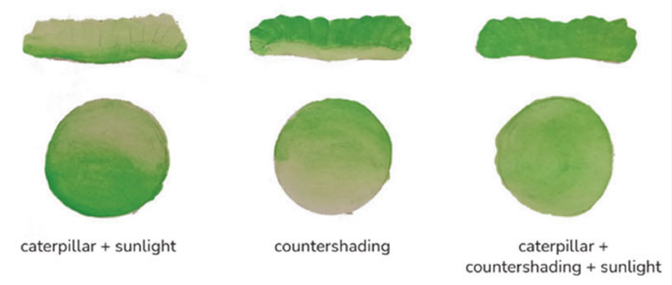

Figure 3.3.d
Source: Shraddha Prabhu

When light falls on a caterpillar, and its belly is a lighter colour than its back, it will appear uniformly coloured, giving it a "flat" appearance that prevents the predator from spotting it against the "flat" leaf.

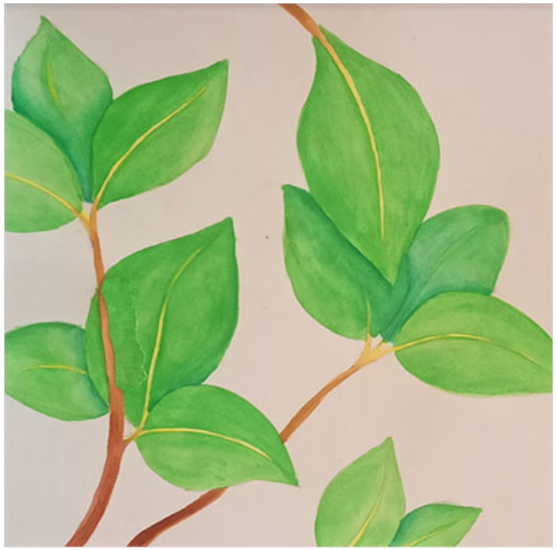

Figure 3.3.e
Source: Shraddha Prabhu

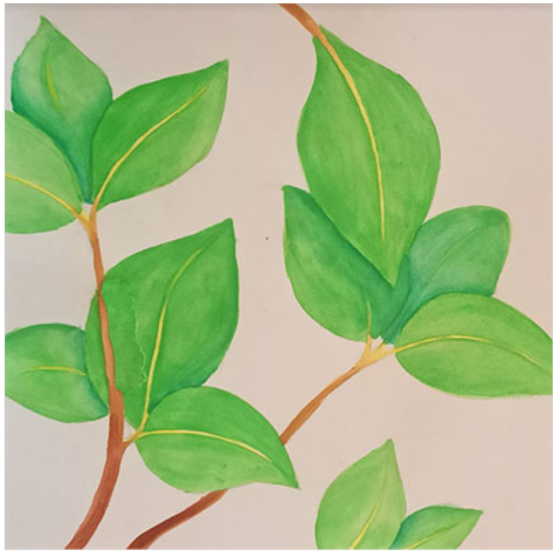

Figure 3.3.f
Source: Shraddha Prabhu

To seem "flat" when exposed to sunlight, a caterpillar that eats upside-down needs to have a belly that is darker than its back. The term for this is reverse countershading.

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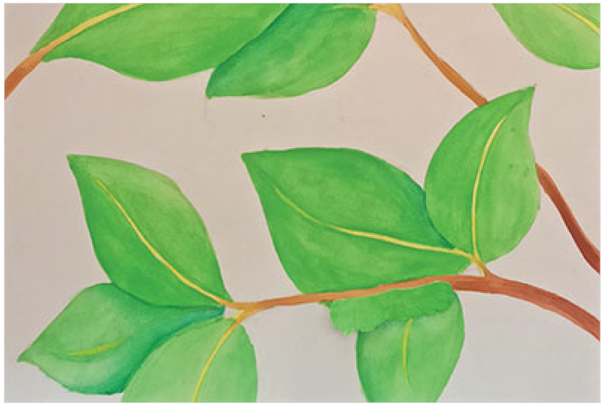

Figure 3.3.g
Source: Shraddha Prabhu

Mimicry: A unique form of camouflage in which an object is disguised to look so much like another object that it is likely to be mistaken for. Such as a caterpillar having a line on its back that resembles the leaf's midrib. This design element will enhance the camouflage. Since the figure and the ground are so close in colour and design, it is difficult to tell the caterpillar from the leaf.

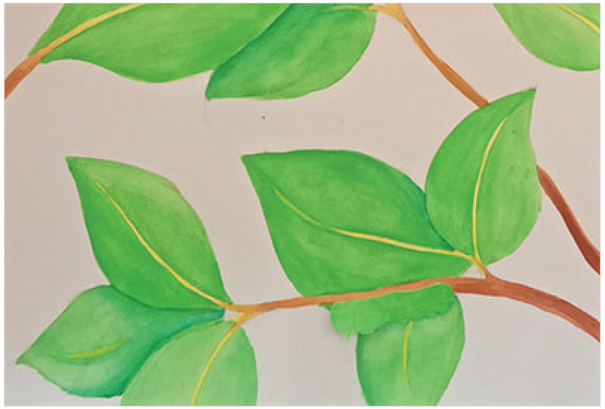

Figure 3.3.h
Source: Shraddha Prabhu

Disruptive: An object's surface can be covered in patterns of sharply contrasting shapes, making it very challenging to identify the object as a single entity—for example, the striking dark patterns on the caterpillar's back. The 'dazzling' pattern creates the illusion (shadows) of numerous sections, making the caterpillar appear to be of various pieces rather than a unified caterpillar. Additionally, this makes figure-ground segregation more difficult.

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IDC, IIT Bombay

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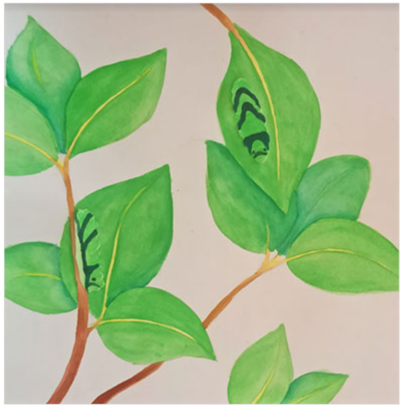

Figure 3.3.i
Source: Shraddha Prabhu

When comparing various camouflage methods, colour has the most significant impact on reducing figure-ground segregation. The colours' hue, value, and intensity must be used at proper levels to create camouflage.

In addition to the above, for camouflage to be successful, it must exploit several Gestalt principles discussed above in Sections 2.3 and 3.1.

Proximity: The camouflage pattern is made to never look like what it is to the casual eye, diverting the brain from perceiving it as a group and ignoring its neural ability. The human mind naturally attempts to group like items by proximity.

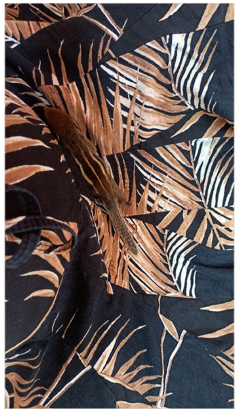

Figure 3.3.j
Source: Shraddha Prabhu

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For example, in the picture above, the pattern on the newborn squirrel's back was matched and aligned with the fabric's design to create a camouflage effect. Due to this, it is challenging to separate the squirrel's complete form from the ground (fabric). Since the squirrel's tail is not concealed, it is simpler to recognize the animal. The pattern alignment is disrupted if the squirrel moves, rendering it no longer disguised.

Good Continuation: The pattern assists in diminishing the outline of the object or organism, which is typically instantly recognized in any environment and may be the most beneficial aspect of camouflage.

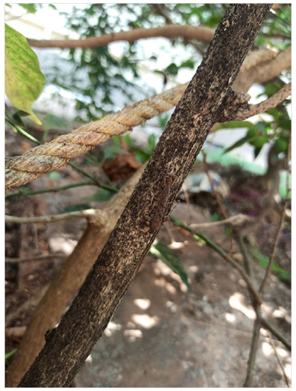

Figure 3.3.k
Source: Shraddha Prabhu

For example, can you see a grasshopper in the picture above? It is not easy to spot. The camouflage pattern is intended to disrupt the caterpillar's form to prevent casual observers from spotting it by searching for a caterpillar's shape.

Another example can be seen in the picture below. An identically coloured moth camouflaged on the metallic leaf in the centre. The moth's structure and the leaf's backside have been matched. The gloss on the leaf has been lined up with the portion of the moth that is lighter in colour. Because of this, the figure-ground separation is challenging enough for us not to see the moth at all.

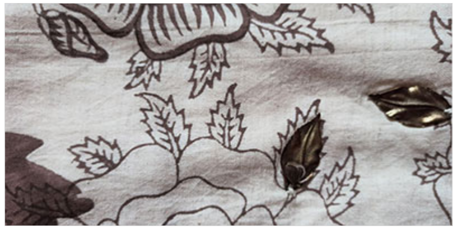

Figure 3.3.l
Source: Shraddha Prabhu

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When we look closely, we can see that the moth's wings are covering the midrib of the metallic leaf. This indicates that the leaf is a background element, and the moth is the figure.

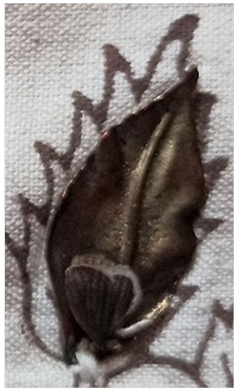

Figure 3.3.m
Source: Shraddha Prabhu

Pragnanz: Let's look at the picture of the girl below. Given the objectives of camouflage, an effective pattern tries to deceive the observer into thinking the wearer is not a human shape right away. Although it is not the same as invisibility, the goal is to keep the brain processing longer. The girl's outfit shares many similarities with the couch's design. As a result, her outfit may appear to be part of the background to us. The figure is only seen with her head lying on her hand.

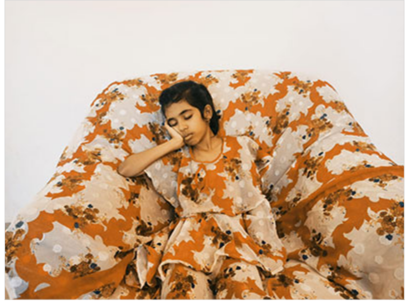

Figure 3.3.n
Source: Shraddha Prabhu

The figure-ground division would have been more straightforward if the dress and the couch were made of plain cloth. The dazzling pattern enhances camouflage by diminishing the shadows. Other patterns (such as stripes) would not have worked due to the discontinuation of patterns between the sofa and the girl—dazzling patterns aid in removing such discontinuity.

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Another example is the picture of a toy dog blending into its background. This image is taken from the top so that only the backside of the toy dog's colour is in view. Due to its similar colour, the toy dog merges with the floor below, making it difficult to see. The dog's features, such as the white patch, which resembles the floor's design, contribute to this camouflage.

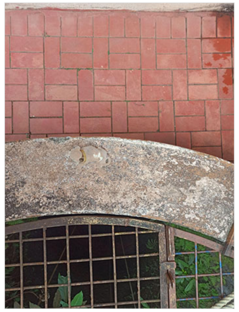

Figure 3.3.o
Source: Shraddha Prabhu

The clues that assist us in distinguishing between the figure and the ground include the break in the neck area, the gold accent, and the dog's faint but distinct shadow.

Other photographic explorations of camouflage.
It's challenging for us to pick out the female on the left-hand rock because she blends in with the background and is bending forward. The rock surface successfully hides her because of the colour, form, and variations in light and shade on her top half.

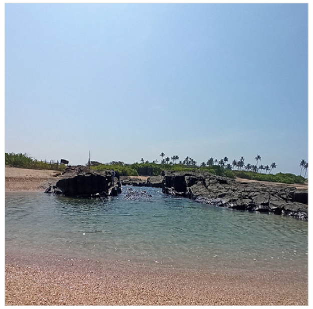

Figure 3.3.p
Source: Shraddha Prabhu

When we zoom closer, we can see that her jeans have a different shape and colour than the rock, making them stand out and allowing us to see her as the figure against the background.

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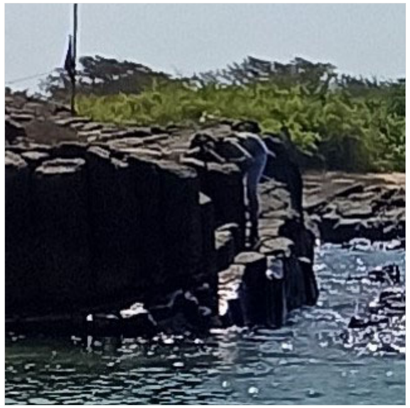

Figure 3.3.q
Source: Shraddha Prabhu

Due to their similar coloration and sunlight falling on them, the flowers the girl is holding in this picture blend in with her outfit. However, the clues that allow us to differentiate between the figure and the ground are the shadows on the flowers and the green stalks.

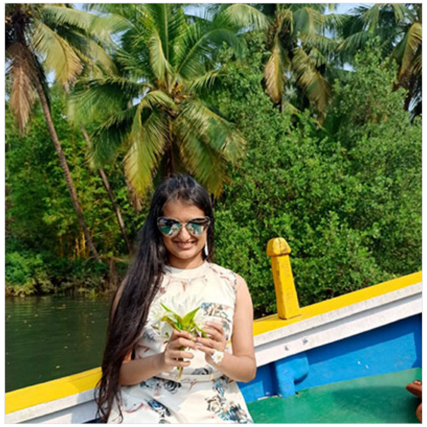

Figure 3.3.r
Source: Shraddha Prabhu

In the picture below, we can see two girls facing the wall. It is challenging to distinguish one from the other because their hair blends due to colour, texture, and shape similarities.

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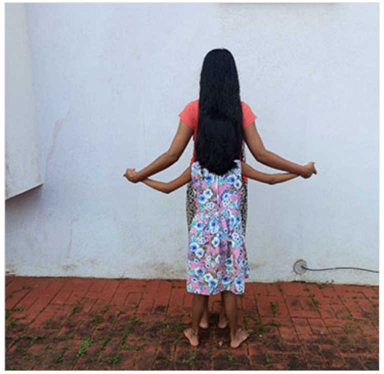
Figure 3.3.s
Source: Shraddha Prabhu

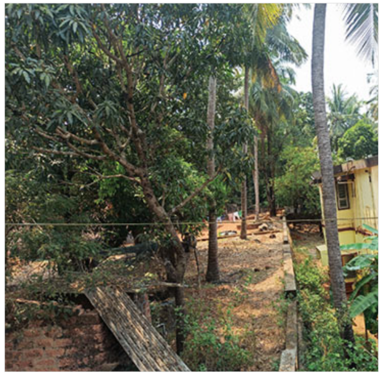
Figure 3.3.t
Source: Shraddha Prabhu

In addition to sharing the same colour as the tree, the positioning of the monkey holding its young in front of the mango tree also serves as camouflage. It is positioned such that it appears to be a limb of a tree continuing into the foliage. When we zoom in, the monkey is easy to see. It is also evident from the tail.

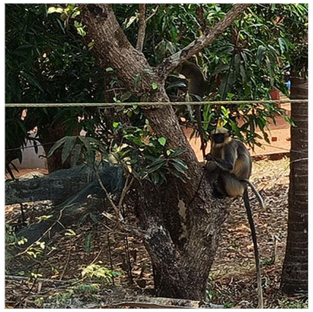
Figure 3.3.u
Source: Shraddha Prabhu

What applications does camouflage have in design?
Plays and movies can utilize camouflage to achieve the desired consequences, such as hiding some items and revealing them afterwards.

When creating patterns for apparel or other surfaces that must blend in with their surroundings, camouflage is used. A wildlife photographer could, for instance, dress in a manner to approach animals up close without startling them. Camouflage has been extensively employed in defence across the world. Finally, creating such patterns gives designers a heightened sense of figure-ground segregation and various challenges concerned with colour and interchange thereof.

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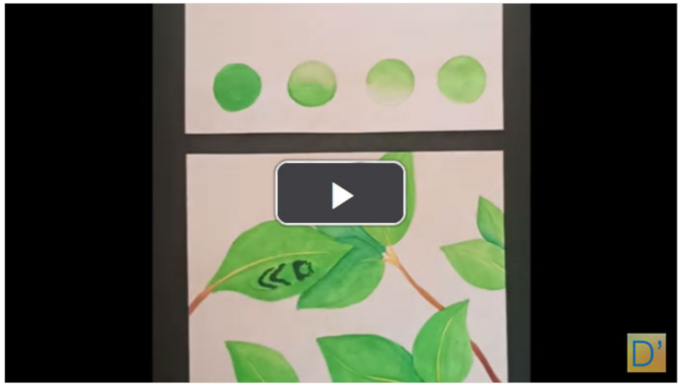
Here is the pdf and video exploring this phenomenon:

- Camouflage......



Source: *Shraddha Prabhu*

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3.4 Embedded Figures

In the previous section, we discussed several types of camouflage. As a reminder, there are four types of camouflage: blending, countershading, mimicry and disruptive. However, there is another type of camouflage known as contour-distorting camouflage, which is based on distorting a figure's contour rather than simply blending into the background. This type of camouflage is effective in breaking up the figure's shape by essentially distorting the contours of the figure's silhouette. In other words, such patterns help decrease the animal's perceptibility in the natural world. Such contour-distorting camouflage manifests itself throughout nature in the form of "boldly contrasting patches of colour that mask the contour of their wearer and break the animal up." Contour-distorting camouflage is most successful when combined with backdrop-matching camouflage and a perceptually complex figure and background. That is why it is far more difficult for predators to target any individual zebra as prospective prey when they stand or move in groups.

Contour-distorting camouflage diminishes our ability to see objects since it frequently uses perceptually complicated figures. One of the defining characteristics of Cubism, as seen in Pablo Picasso's "Portrait of Wilhelm Uhde," is contour distortion. The intention was to blur the lines of figure-ground separations by distorting contours. The forms in the movements are made such that it combines with the space around them or with other forms, where tones or planes blend into one another, and outlines coincide before unexpectedly re-emerging in new relationships.

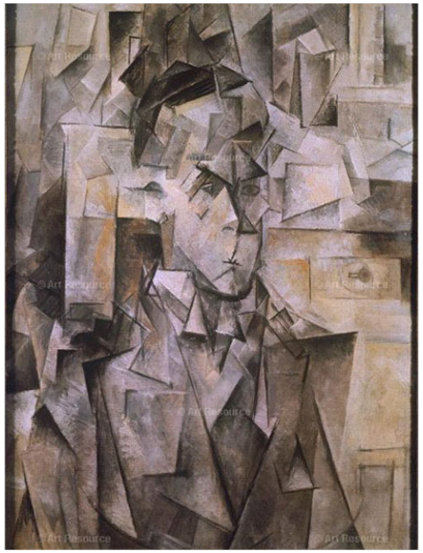

Figure 3.4.a
Source: Portrait of Wilhelm Uhde © ARS, NY. Photo Credit: Bridgeman-Giraudon/ Art Resource, NY

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Following this movement, Guirand de Scévola recruited Cubist artists in World War I to "obliterate objects" and prevent the recognition of objects. Numerous soldiers who had previously worked as artists in the civilian world were tasked with camouflaging. The "laws of organization" that Gestalt psychologists had proposed were also developing simultaneously.

Kurt Gottschaldt created The Embedded Figures Test in 1926. The test was inspired by the cognitive challenge of identifying figure-like entities embedded in perceptually complicated combinations. This test measures our capacity to cognitively separate figures from their background and identify recognizable shapes "hidden" in intricate designs.

Multiple practical examples use the theory of embedded figures in everyday life. From finding hidden "Disney" throughout Disney theme parks to hidden picture puzzles such as I-Spy or Spot it that we play with kids to the book "Where's Waldo?" use the same idea of embedded figures. It is also used in word search games where we have to find the actual word in a grid of scrambled words.

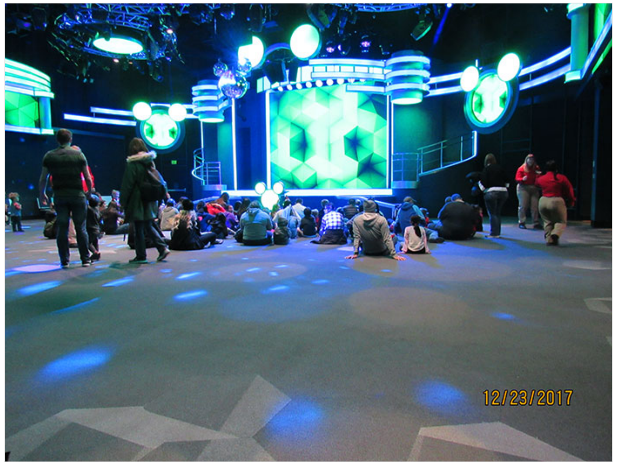

Figure 3.4.b
Source: Sruthi Sridhar

Embedded figures are images that allow one to visually identify and distinguish local components within a larger configurable shape or to select a simple figure from a bigger image. When the lines of a simple figure perceptually belong to a broader picture, it becomes more challenging to distinguish between the two.

The explorations below attempted to comprehend the various methods of figure embedding and explore a few different Gestalt laws. The first exploration is a simple geometric one with a face embedded within the polygons. In this image, the eyes can visually locate elements of the face at a global level.

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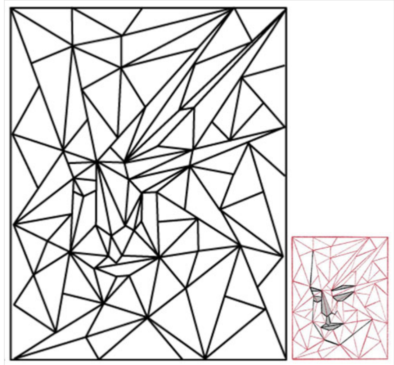

Figure 3.4.c
Source: Lakshmi Chandran

A "busy" design undermines the capacity to recognize an object's shape, jeopardizing the perception of the object's wholeness. An object may no longer appear to be a single, perceptually cohesive entity if it has a lot of "interior detail that is more salient than its edges," leading potential perceivers to believe that they are witnessing multiple objects. While a figure may no longer be viewed as a separate entity when it is arranged to blend or match its surrounding context, altering a figure's contours makes it more challenging to recognize it as a single thing.

On the contrary, finding the embedded figure becomes more challenging as the image becomes simpler. In the exploration below, there is nothing but branches. The exploration focused on creating a Hand emerging out from the thin branches. But one can identify it only after being pointed out. The image is much harder to pick out as the details are fewer.

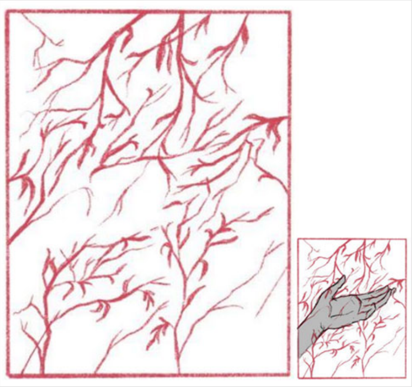

Figure 3.4.d
Source: Lakshmi Chandran

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As discussed before, figure-ground segregation is the ability to identify the boundaries or contour in an image. In the image below, a boundary appears between the leaves and the dark shadow within to create a side profile of the face. The change in the quality of luminance here allows us to identify the face due to depth. This exploration uses a range of greens, so the embedded figure tends to blend in with the ground.

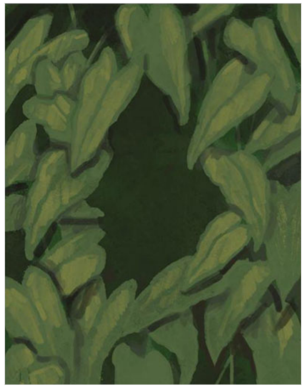

Figure 3.4.e
Source: Lakshmi Chandran

The exploration tried a contrasting colour to understand the effect of embedded figures. Through this, it is clear that the figure to be embedded/ hidden stands out very clearly, i.e., the figure stands out from the ground and is no longer confounded. And in this image, the area occupied by the figure also overpowers the effect.

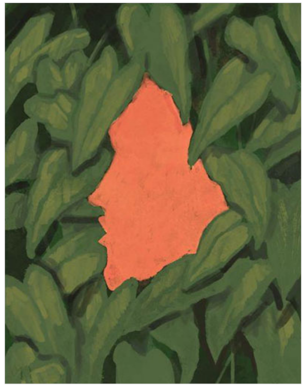

Figure 3.4.f
Source: Lakshmi Chandran

Original figures can be downloaded here:
- Embedded Figures......

Source:
https://www.dsource.in/course/visual-perception-communication-designers/3-figure-ground-segregation/35-illusory-contours

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3.5 Illusory Contours

The fundamental building blocks of visual perception are surfaces and contours. An object's surface should ideally be represented by closed contours typically expressed by concurrent areas that change in luminance, texture, or colour. This ensures that local contour information can easily be extracted by the cells in the primary visual cortex. The cells can then send the signal through a hierarchy of visual processing steps that enable the perception of surfaces and objects. However, when local image information lacks sufficient cues like brightness, texture, or colour, the human visual system is still quite proficient at recognizing visual contours. These contours are referred to as "illusory contours."

Since illusory contour displays are helpful tools for researching contour and surface perception, illusory contours have been explored for more than a century. There are three primary mechanisms which can explain how illusory contours work. The first is contour interpolation, in which the mechanism suggests that we internally connect pairs of aligned segments to close "edges" across gaps. For example, in the diagram below of the Kanizsa triangle, we connect aligned segments even though there are no physical cues to perceive the triangle in the middle.

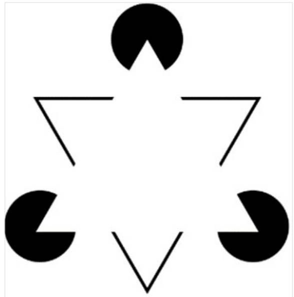

Figure 3.5.a
Source: Swati Yadav

The second theory is contour extrapolation, in which one extends beyond a single fragment. For example, look at the picture below.

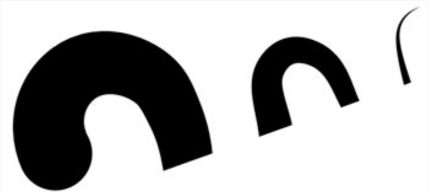

Figure 3.5.b
Source: Swati Yadav

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In your mind, does the image resemble picture A or B? We imagine the diagram to look like a snake rather than what is displayed in B.

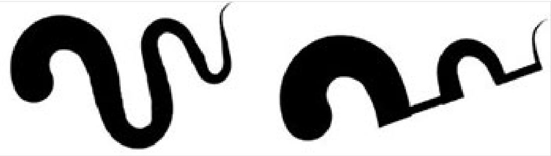

Figure 3.5.c
Source: Swati Yadav + Sruthi Sridhar

Finally, the figural-feedback mechanism proposes that the contour pieces help create the perception of a surface or a figure. This figural representation feeds back to fill any contour gaps. In the examples above, we "perceive" the missing contours to be the shape of a triangle and a snake. Hence, we fill it up with those shapes.

Here are some explorations of illusory contours Adaptations of the Kanizsa triangle and square:

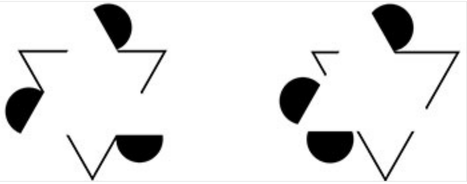

Figure 3.5.d
Source: Swati Yadav

The Kanizsa triangle has a white, equilateral triangle in the centre that looks like it is occluding the shapes on either side. It also looks like the non-existent white triangle is brighter than the background, although it is the same brightness. The illustration given in the example above (Figure 3.5.d) is the original Kanizsa triangle; below are some explorations.

Even when the triangle's orientation changes, we can still interpolate the edges of the equilateral triangle in the middle.

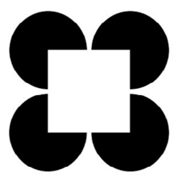

Figure 3.5.e
Source: Swati Yadav

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Similarly, here is the original Kanizsa square.

The white border of the square seems visible as long as occluded shapes define its four sides and a few corners.

However, if the placement of the occluded circles does not precisely delineate the corners of the square, the white contour of the square looks stretched.

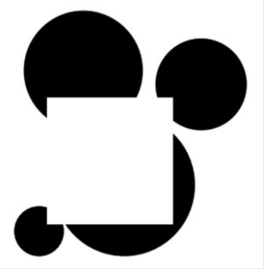

Figure 3.5.f
Source: Swati Yadav

Here are some explorations.

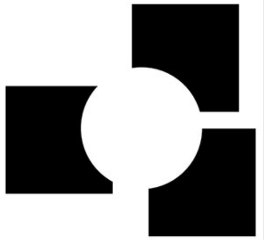

Figure 3.5.g
Source: Swati Yadav

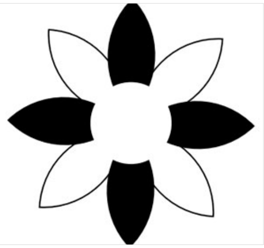

Figure 3.5.h
Source: Swati Yadav

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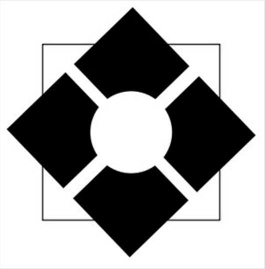

Figure 3.5.i
Source: Swati Yadav

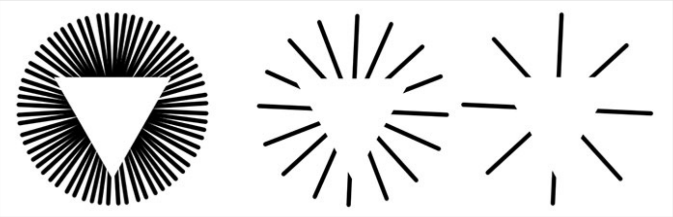

Figure 3.5.j
Source: Swati Yadav

Here are some explorations using text:

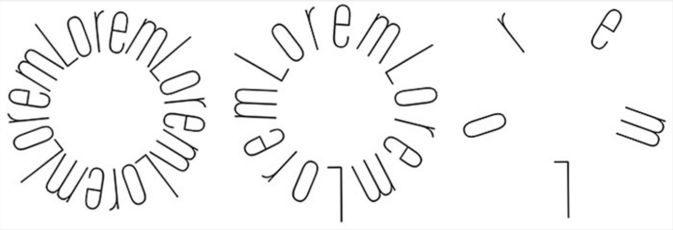

Figure 3.5.k
Source: Swati Yadav

Letters, when arranged in ways, can create an illusory contour. However, when the spacing (kerning) of the letters is increased, the contours become less pronounced.

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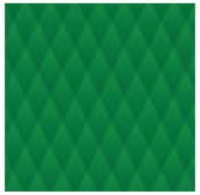
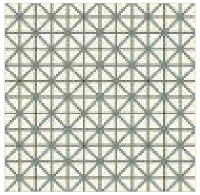
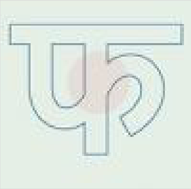


4.1 Cornsweet Illusion

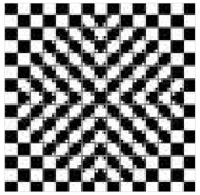


4.2 Grid Illusion

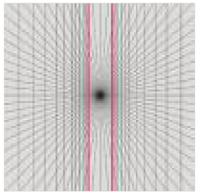


4.3 Poggendorff Illusion

4.4 Muller Lyer Illusion

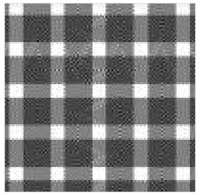


4.5 Bulging Checkerboard



4.6 Herings Illusion

4.7 Orbison Illusion



4.8 Zollner illusion

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4.1 Cornsweet Illusion

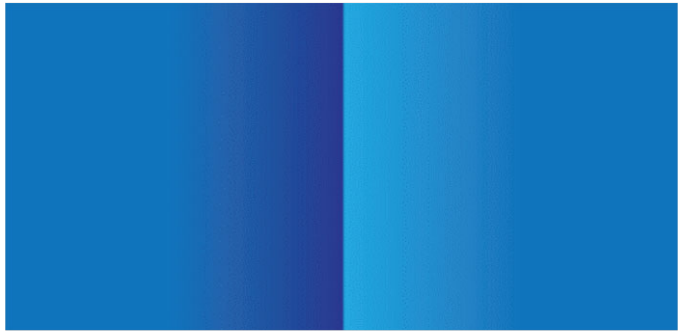

Figure 4.1.a
Source: Shraddha Prabhu

If we carefully observe the picture above, the squares seem to start with a lighter shaded blue and transition to a darker shaded blue. If one asked, “which of the two squares seems darker to you?” you would probably say the square on the left-hand side appears darker than the square on the right-hand side this is the Cornsweet illusion.

The Cornsweet illusion, also known as the Craik-O’Brien-Cornsweet illusion or the Craik-Cornsweet illusion, is an optical illusion in which a gradient within a central line or segment gives the impression that one side of a picture is darker than the other when both areas are identical. It was detailed in the late 1960s by Tom Cornsweet.

Two squares of varying contrast appear to be divided by a thin gradient band in the classic Cornsweet illusion. In actuality, the contrast between the two squares is exactly the same. In some instances, the illusion is so compelling that the only way to accept it is to conceal everything except the two identical colours, confirming that they are actually the same shades of a colour. For example, it becomes clear that they are the same shade of blue when you look at the picture below when the gradient is removed.

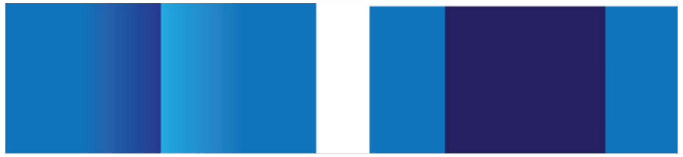

Figure 4.1.b
Source: Shraddha Prabhu

The Cornsweet illusion occurs due to the luminance difference (contrast) at the edges of the surface. Surfaces with bright edges are viewed as significantly lighter than those with dark edges.

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This backs up the theory that the surface traits that define the edges are interpolated to reconstitute the surface's perception (in this case, brightness). The Cornsweet illusion is an example of how the brain uses the edges of shapes to transfer information to the surrounding areas regarding other characteristics.

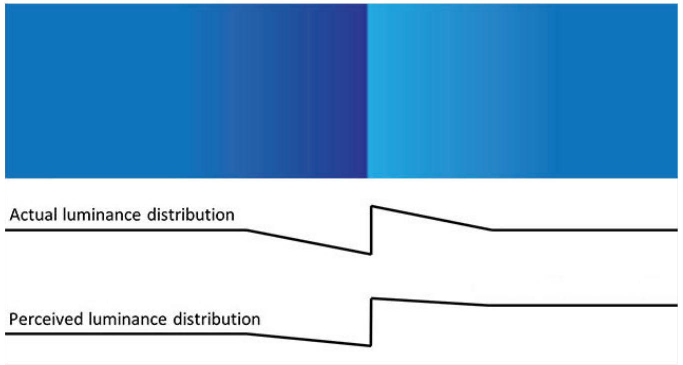
Actual luminance distribution
Perceived luminance distribution

Figure 4.1.c
Source: Shraddha Prabhu + Sruthi Sridhar

The illusion is caused by previous experiences with luminance sources and gradients from shading in our 3D environment. Even though the two sections on each side of the brightness gradient are similar, the area on the right looks brighter because it is shaded as if illuminated from the left, triggering compensation of illumination by discounting the very light. The retina uses luminance profiles to evaluate what it sees. The left square is almost used as a fixpoint for the perception of the rest of the picture. The Cornsweet image is interpreted with nearly identical signals, which are subsequently integrated by the cortex to provide the same perceptual outcome.

Graphic designers use the insights from the Cornsweet illusion all the time to develop patterns and other contrast effects, using the difference in luminance gradients in their work. Let us see one process of exploration of these patterns. In the image below, if you were asked which row of diamonds looks the darkest in the picture below, what would your answer be?

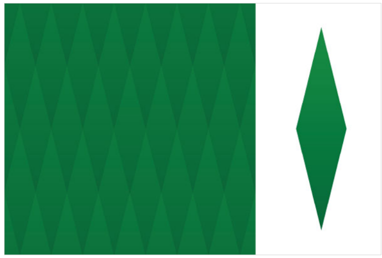

Figure 4.1.d
Source: Shraddha Prabhu

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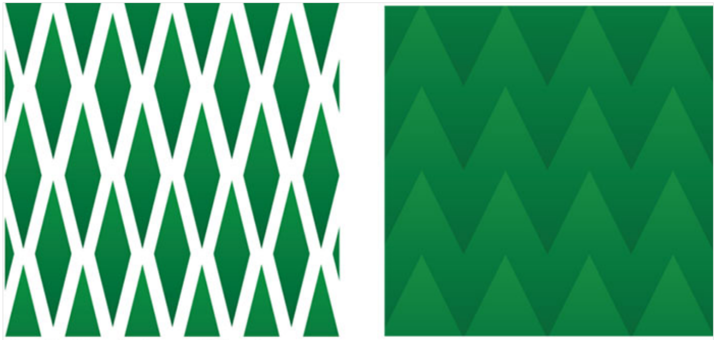
You probably would be tempted to say that the top row of diamonds looks the darkest. However, each one of these diamonds is exactly the same. They look different due to the cumulative Cornsweet effect.

Each diamond has a subtle gradient where it becomes darker towards the bottom. The diamonds are arranged in a pattern such that a lighter shade always surrounds the darker bottom of the diamond. Diamonds adjacent to the darker section of the gradient appear lighter, whereas diamonds near the lighter portion appear darker. Therefore, we get a cumulative Cornsweet effect where the topmost row of the diamond appears darker than the bottom row, which translates into the overall perception of the top row of diamonds as the darkest and the bottom row to be the lightest. As a result, our brain believes that the diamonds become darker as they progress to the top.

How to design a convincing Cornsweet illusion?

1. The gradient of the shape must be subtle enough. The illusion diminishes if the gradient is either too pronounced or too muted. If it is too pronounced, the brain easily perceives the similarity of the gradient. However, if it is too muted, the brain might not pick on the Cornsweet effect.

2. The shapes must be adjacent to one another to ensure the illusion works.



The effect is not observed if the shapes are not adjacent.

It can occur in various repeating shapes, as long as they are adjoining.

Figure 4.1.e
Source: Shraddha Prabhu

3. The gradient must be spread out over an appropriate area. For example, reducing the height of the diamond diminished the illusion.

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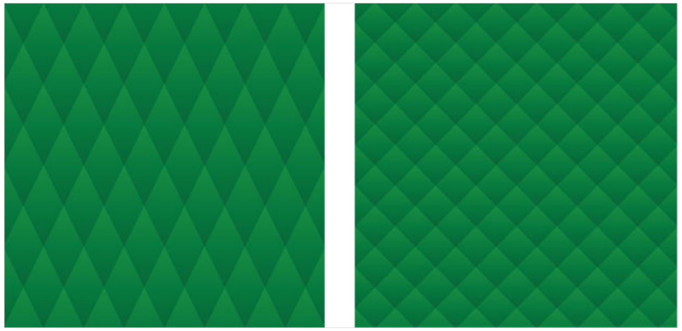
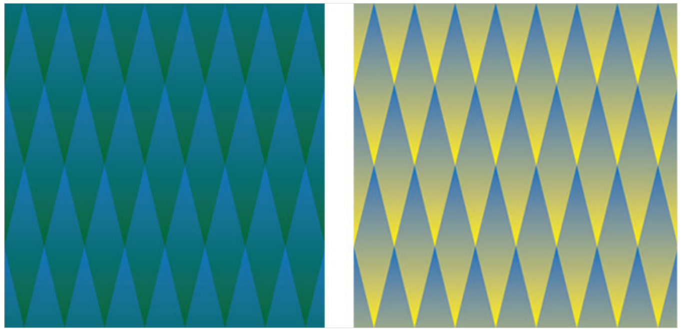


Reducing the height of the diamonds decreases the Cornsweet effect substantially since one can easily perceive the gradient here.
Figure 4.1.f
Source: Shraddha Prabhu

4. The gradient must be in one shade or monotonous. Multiple shades are perceived easily by the brain. Therefore, perception would not depend on the shade's brightness; instead, it would depend on the hue or the colour itself.



Cornsweet effect cannot be observed in multiple colour gradients. Keeping it monochromatic is the key.
Figure 4.1.g
Source: Shraddha Prabhu

5. Make sure there is no border around the shape, as it will significantly diminish the illusion.

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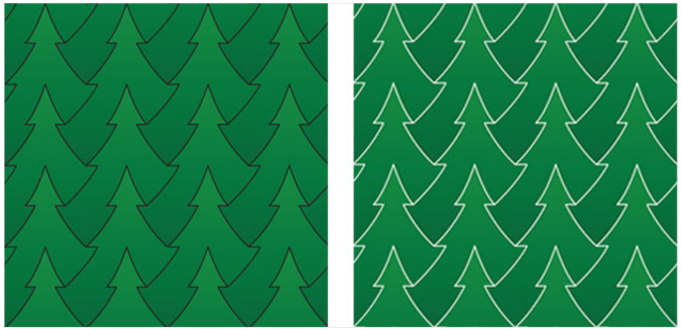

Borders around the shapes decrease the effectiveness of the Cornsweet illusion by enhancing the gradient within individual objects.
Figure 4.1.h
Source: Shraddha Prabhu

Here is the pdf exploring this phenomenon:
- Cornsweet Illusion ......

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4.2 Grid Illusion

Do you see dots popping up in the structure below? Can you see all the dots on the design below at once?

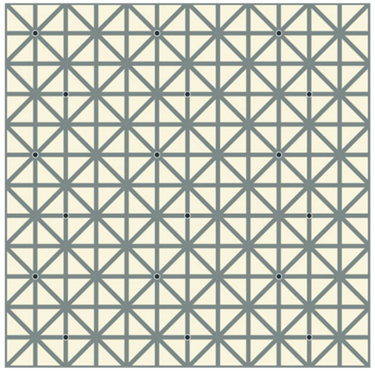

Figure 4.2.a
Source: Rachana Sankhalker

This is a type of grid illusion. Any grid that deceives a person's vision is called a grid illusion. The two most prevalent grid illusions are the Hermann grid and the Scintillating grid. However, the visual phenomenon above is an example of an extinction grid. It is also known as Vanishing Dots. The extinction grid incorporates the findings from Hermann Grid and the Scintillating Grid. It was found that the scintillation effect gives way to an extinction effect as the size of the black dots is reduced to the width of the alley or smaller.

Overall, the dot in focus and perhaps one or two other dots in proximity are visible at any given time, while the remaining dots appear to form a homogeneous network of grey lanes. While scanning the entire grid, the surrounding environment fills in, and new clusters of dots are discovered. In addition, the dot on a six-line intersection has a more significant local grey-scale contrast than the dot on a four-line intersection.

How do the Hermann Grid and the Scintillating Grid illusion differ?

Hermann Grid Illusion

Ludimar Hermann originally described the Hermann grid illusion in 1870. Ewald Hering discovered in 1872 that inverse colours (a black grid on a white background) yielded comparable results. As a result, the Hermann grid is sometimes known as the "Hermann-Hering" grid. A grid of black squares on a white background creates the Hermann grid illusion. At the intersections of the white lines, "ghostlike" grey figures can be seen. When one looks directly at an intersection, these figures disappear.

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The Herrmann grid depends on a physiological phenomenon of lateral inhibition at the neurons' levels. At the retinal level, neurons constantly excite or inhibit nearby cells depending on how they are stimulated. The lateral inhibition and excitation process improves the contrast at contours, slightly exaggerated, between dark and light regions.

The formation of ghostlike figures does not take place at fixated intersections. Instead, it takes place in the peripheral vision or the intersections that are present outside our fovea. Because of its tiny receptive field and dense concentration of photoreceptors, the fovea has relatively minimal lateral inhibition when you are gazing directly at a junction in the Hermann Grid (yellow circle). We perceive this area to be either white or light grey, which is a reasonably accurate perception of this area. Since the dark and light regions are evenly distributed within the orange circle, no gain adjustment is necessary, and this region appears white to us. Most of the receptive field is saturated with white light at the peripheral intersections (green circle), resulting in significant lateral inhibition, reducing gain, and creating a grey area.

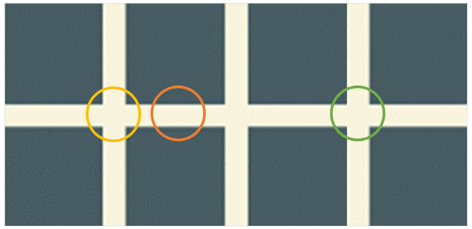

Figure 4.2.b
Source: Rachana Sankhalker + Sruthi Sridhar

This illusion holds for various geometric versions of the Hermann Grid, such as rounded corners and non-orthogonal alleys. In such circumstances, patches of grey can be seen rather than dots.

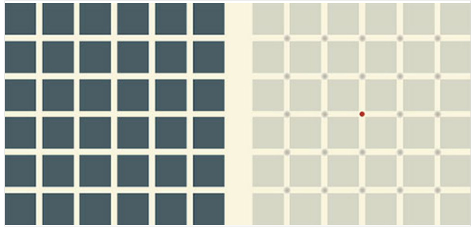

Figure 4.2.c, d
Source: Rachana Sankhalker

How to design a good Hermann grid illusion?

Does the number of grids and their color make a difference?

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As seen below, one cannot achieve the illusion with a 2x2 grid. Therefore, a minimum of 3x3 grid is required to achieve the illusion.

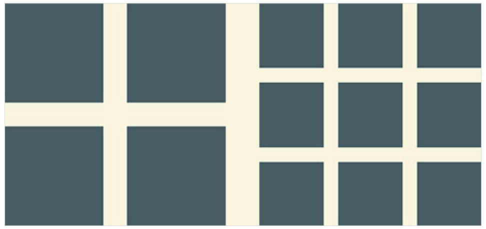

Figure 4.2.e, f
Source: Rachana Sankhalker

The illusion is highly robust with uniform grey squares. However, it can be seen in a diminished version of the Hermann grid with colored squares.

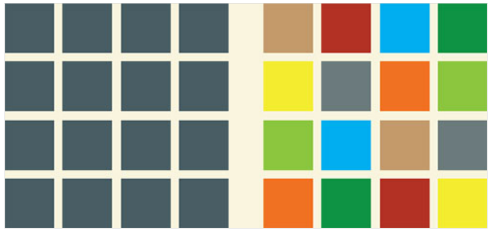

Figure 4.2.g, h
Source: Rachana Sankhalker

Do the characteristics of the alley, like the width and colour, impact the illusion?

The space between the grid is critical, as the illusion is non-existent when the alley's width is reduced. On the other hand, when the alley's width is non-uniform or too wide, this diminishes the illusion.

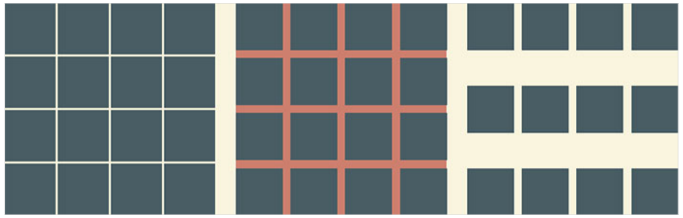

Figure 4.2.i, j, k
Source: Rachana Sankhalker

Source:
https://www.dsource.in/course/visual-perception-communication-designers/4-edges-lines-and-angles/42-grid-illusion

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It is also essential to have an alley with an appropriate colour as the illusion becomes weaker if the alley or the background is coloured.

Scintillating Grid Illusion

Elke Lingelbach discovered the Scintillating grid illusion in 1994, commonly considered a variant of the Hermann grid illusion. Lingelbach and co-workers reported their findings in "The Hermann grid and the Scintillation Effect." The construction of the scintillating grid illusion is similar to the Hermann grid. Instead of white bars, grey bars with white discs placed at each intersection are used. Black dots appear and disappear as viewers move their eyes over the image. Eye movement enhances the illusion, while moving too close or too far away from the image diminishes the illusion.

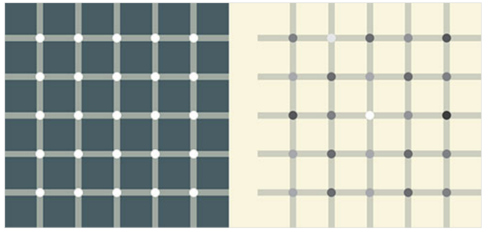

Figure 4.2.l, m
Source: Rachana Sankhalker

How to design an adept Scintillating grid illusion?

Along with the guidelines provided for the Hermann grid above, further explorations were done with the Scintillating grid.

Turning the grid by 45º, the Scintillating Grid illusion is achieved. Here the dots are slightly bigger than the width of the alleys.

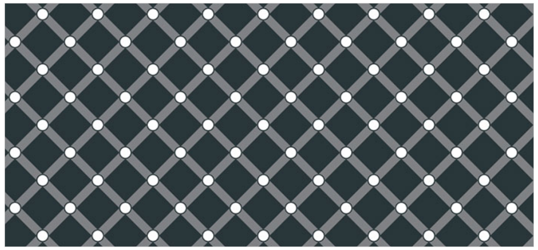

Figure 4.2.n
Source: Rachana Sankhalker

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An extinction effect may be seen in the same grid as the diameter of the dots is reduced. Most of the dots in the vicinity of focus disappear when the eyes are moved and then held in fixation. The other alleyways appear uniform in brightness.

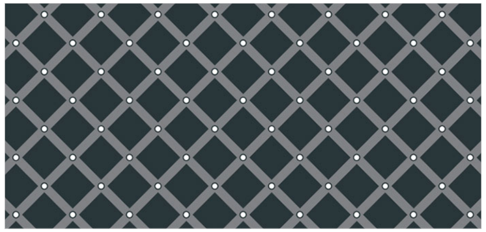

Figure 4.2.o
Source: Rachana Sankhalker

How do these grids work?

The visual system enhances the edges of things by processing them. For the brain to comprehend and characterize an image, seeing boundaries is crucial. Occasionally, this causes visual "artefacts" to appear outside of the receptive area, like the black dots in the Hermann grid.

As we have seen above, the illusion exists in rectilinear shapes. However, does it hold in non-orthogonal shapes and patterns?

In further exploration, one found that the illusion stays intact with rounded corners. However, the illusion is weakened if the rounded corners are not aligned. The illusion becomes weak if the rounded corners are structured in a staggering orthogonal grid.

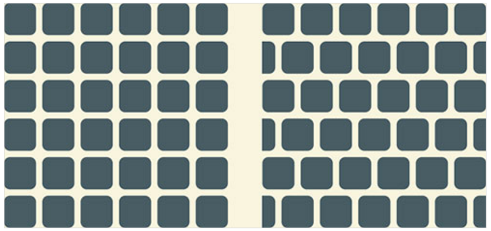

Figure 4.2.p, q
Source: Rachana Sankhalker

Moreover, in terms of other patterns, the illusion is slightly diminished with squares of different grey shades and outlines with the thick grey line. Furthermore, the illusion stays intact with a repetitive pattern of rectangles and squares. In the picture below, you can see dots and grey patches of grey throughout the pattern.

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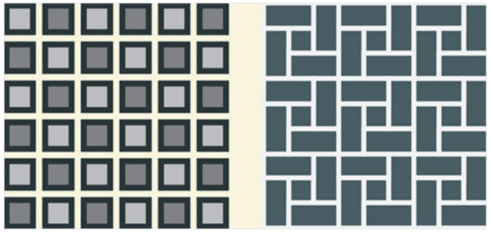

Figure 4.2.r, s
Source: Rachana Sankhalker

- Grid Illusion......

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4.3 Poggendorff Illusion

Please focus on the black paddle and follow it downwards. Which path would it follow? Do you think it will follow the course of the red or the blue paddle?

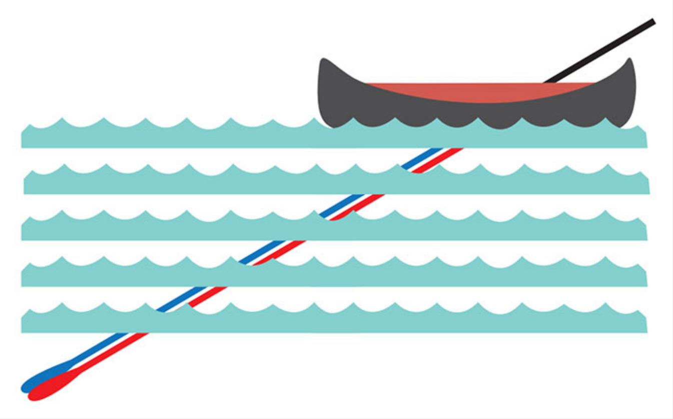

Figure 4.3.a
Source: Divya Gaur

Although the black paddle appears to continue with the red paddle, it continues with the blue one. This is the Poggendorff illusion, where when the continuity of an obliquely oriented line is interrupted, the positions of the line segments on either side of the interruption appear to be shifted vertically or horizontally depending on the orientation of the interruption.

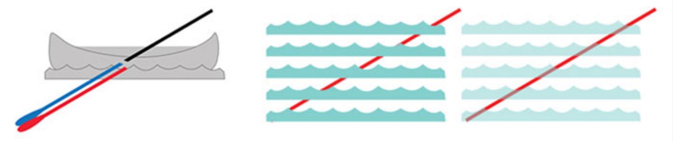

Figure 4.3.b
Source: Divya Gaur

The Poggendorff illusion is an optical illusion involving the brain's perception of how diagonal lines interact with horizontal and vertical edges. Johann Poggendorff, a German physicist, first described the Poggendorff illusion in 1860. The Poggendorff Illusion is one of several optical illusions. The illusion has a core aspect of a simple line image – such as line length, straightness, or parallelism – that is warped by other elements of the image, such as background/foreground lines or other intersecting features. It is an example of geometrical-optical illusions.

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The Poggendorff illusion is a visual illusion in which narrow diagonal lines seem angled behind wider stripes. Let us take a look at the picture below. In the diagram to the far left, the thin lines appear misaligned, and there is a perception of offset when the same line continues. However, when the line is shifted up slightly (the image to the far right), there is a sense of continuation.

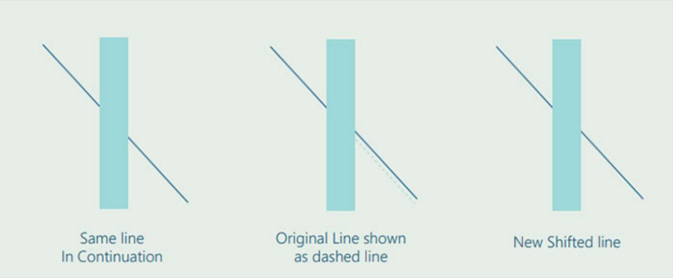

Figure 4.3.c
Source: Amit Patjoshi

Why does this illusion occur?

While the real reason for the Poggendorff illusion is unknown, scientists have proposed a variety of possibilities, the two most prevalent of which are described below.

The first is based on the principle of angular displacement. According to the angular displacement theory, the brain overestimates all acute angles while underestimating all obtuse angles. The grey foreground rectangle that intersects the thin straight lines causes the visual system to exaggerate the orientation contrast between the lines and rectangle—that is, to 'expand' the acute angles at the relevant intersections. This, in turn, gives the illusion of a misalignment of lines. However, the illusion does not seem to sustain during a rotational change complicates the acute-angle expansion concept in the case of the Poggendorff Illusion.

Another explanation along the same lines would be lateral inhibition theory, leading the retina cells to behave differently at different angles when detecting contour orientation. As a result, the two lines' orientations would appear to be on different trajectories. However, the critics of this theory point out that the illusion is still intact when the middle bar is eliminated. The illusion does not appear to depend on lateral inhibition of the contour-orientation cells when no contour is present.

The depth-processing or consistency theory claims that the figure is processed as a three-dimensional entity rather than a two-dimensional figure. According to the hypothesis, the central rectangle is processed by the brain as a three-dimensional figure that appears on a plane directly in front of the observer, while the diagonal lines are interpreted as horizontal planes that recede away from the viewer. Obtuse angles are underestimated, and acute angles are overestimated, although for different reasons than the angular displacement theory. The effect is caused by a misconception of perspective representation rather than two-dimensional distortion.

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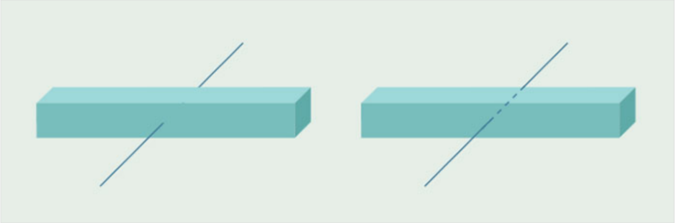

Figure 4.3.d
Source: Amit Patjoshi

Unfortunately, the depth processing theory fails to explain other variations of the Poggendorff illusion. When the Poggendorff figure is rotated, the diagonal intersecting lines are oriented vertically, reducing the illusion's impact, or disappearing the effect altogether.

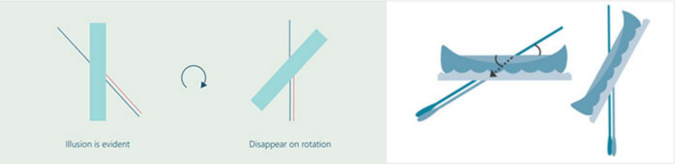

Figure 4.3.e
Source: Amit Patjoshi

How does the illusion change with angles? Here are a few explorations that examine how changing the orientation of the thin and thick lines changes the illusion's impact.

Situation 1: When the thin line is vertically fixed, and the thick bar rotates behind it.

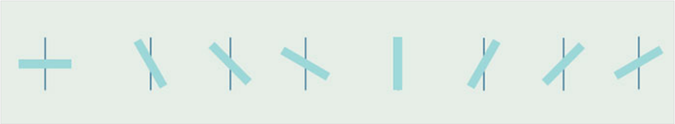

Figure 4.3.f
Source: Amit Patjoshi

In this situation, the illusion becomes more evident as a distinct acute and obtuse angle is formed between the lines (as shown in the second image from the left and the third image from the right). The illusion is lost when the lines connect at right angles (first image).

Situation 2: When the thick bar is vertically fixed, and the thin bar rotates.

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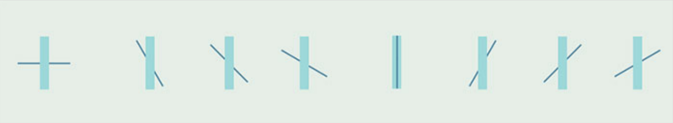

Figure 4.3.g
Source: Amit Patjoshi

The illusion is extremely similar to that in the previous situation. The angles formed are relative in both circumstances.

Situation 3: When both the lines are thick, and one is rotated.

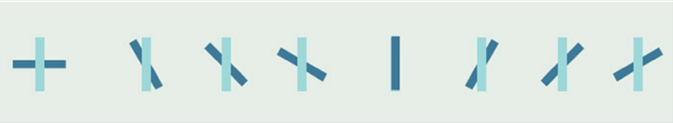

Figure 4.3.h
Source: Amit Patjoshi

In this scenario, the illusion is more pronounced when the angle is more acute but less pronounced compared to the previous two scenarios where the lines were of different widths.

Does Poggendorff's illusion occur with curves?

Situation 1: When the thin line is vertically fixed, and the thick line is curved.

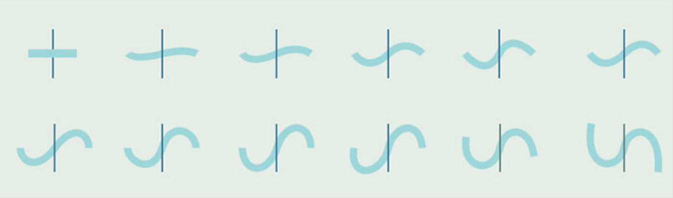

Figure 4.3.i
Source: Amit Patjoshi

The straight line was kept constant as the curve's amplitude steadily grew. The nodes of the Bezier curves were kept unchanged throughout the exploration, and the exploration stretched only the handles to enhance the curve's amplitude. Several trials discovered that a dent in the curve appeared after reaching a certain point, which could only be seen when the curved line was thick.

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Regardless of the curve's amplitude, when the straight line was thin and the curve was thick, it severely diminished the illusion in situation one.

Situation 2: When the thick line is vertically fixed, and the thin line is curved.

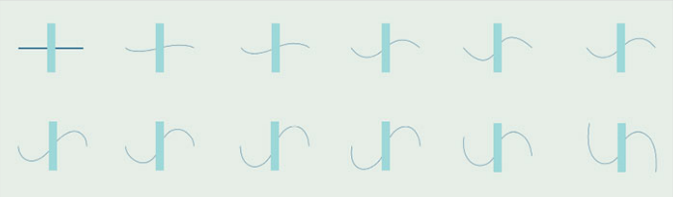

Figure 4.3.j
Source: Amit Patjoshi

The illusion got more prominent as the magnitude of the thin line increased in the following situation. The illusion occurs here as opposed to situation one due to the thick line's obscuring effect.

Situation 3: When both the straight and the curved lines are thick

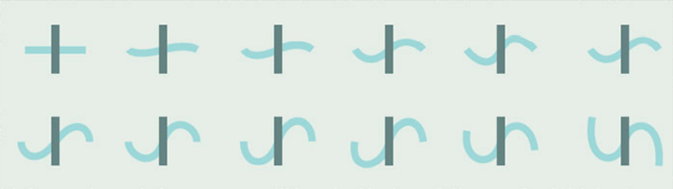

Figure 4.3.k
Source: Amit Patjoshi

The illusion exists here because of the obscuring, but the effect is slightly less than circumstance two.

The Poggendorff illusion, like other perceptual illusions, allows scientists to investigate how information is received and interpreted by the brain and the human visual system. One can find the Poggendorff illusion in various settings in everyday life, such as fonts. Because the Poggendorff illusion is a universal phenomenon, it can occur in any script. It appears prominently in the letter 'X' in the Latin script.

The intersection of two straight strokes at an angle and the masking produced by the intersection are the two key reasons why the illusion appears prominently in the letter X.
Optical correction is applied in various ways to counterbalance the illusion depending on the type of font. With the help of several fonts, the same has been depicted below. The serif font is called 'Playfair Display,' the sans serif font is called 'Poppins,' the Italic fonts are also from the Poppins family, and the slab serif is named 'Trend Slab.'

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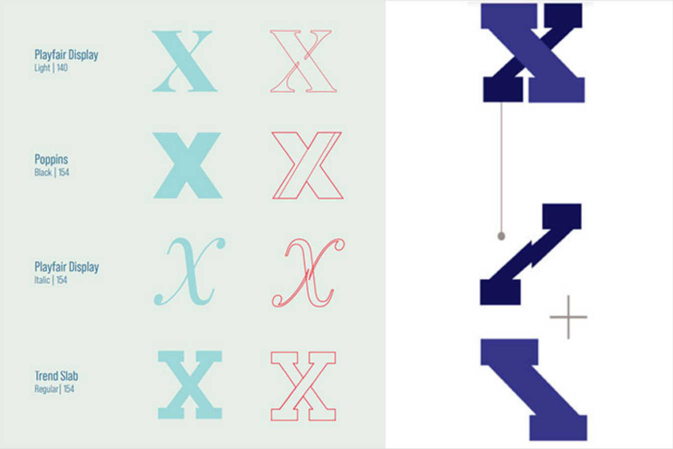

Figure 4.3.l, m
Source: Amit Patjoshi and Source: Soham Kadwaikar

How does the weight of the font impact the illusion?

The examples above show that the illusion is apparent when a thin line crosses a thick line. However, when it appears in the letter’ x,’ the amount of illusion varies depending on the letter’s weight.

The lighter weights lead to a diminished illusion, requiring minor corrections. However, as the weight increases, the illusion becomes more pronounced, necessitating a more significant change in the stroke to offset the illusion.

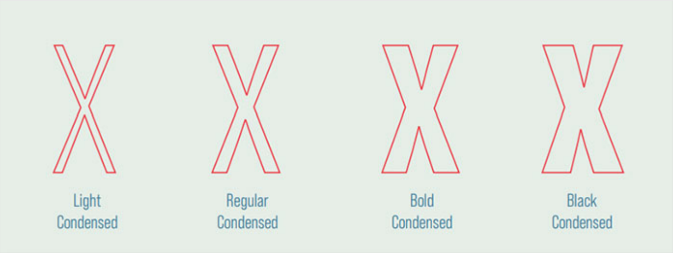

Figure 4.3.n
Source: Amit Patjoshi

How does the width of the font impact the illusion?

Given that the weight of the letters is the same, the illusion appears weaker on stretched letters than on condensed letters when it comes to letter width. This could be because the acute angles are more evident with condensed weight, and the brain exaggerates the acute angles, making the illusion more prominent.

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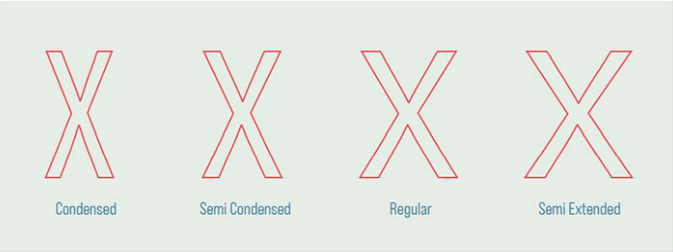

Figure 4.3.o
Source: Amit Patjoshi

Does the Poggendorff illusion persist in the Devanagari script as well?

Devanagari script is a combination of both straight and curved lines. And there is an exploration of the letter 'फ' done in the example below. The curved and straight lines appear to have the same thickness in the exhibited example since it is a nonlinear font. The effect is slight since the thicknesses are similar. The filled and outlined versions of the same letter are shown in the illustration. The filled curved stroke appears to be continuous, owing to the correction made by moving the right stroke slightly up, as shown in the outline version.

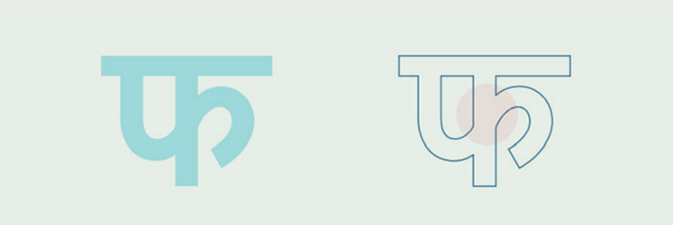

Figure 4.3.p
Source: Amit Patjoshi

In Devanagari, some characters also display signs of illusion. However, unlike the original illusion, these are visible at the points where curved intersections are used. Some of the letters in 'Poppins' Devanagari are bolded to illustrate the examples better. The letter 'Tra' is written in the Nirmala UI typeface.

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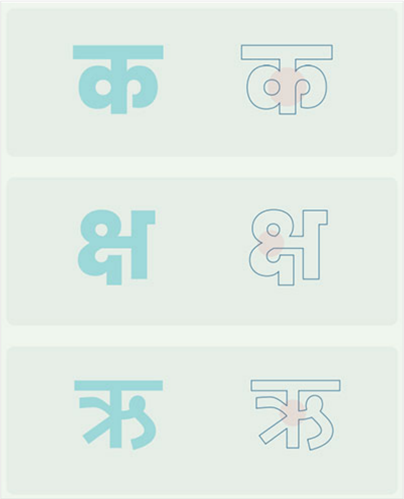

Figure 4.3.q
Source: Amit Patjoshi

As previously noted, the illusion exists independently of the script. The illusion is also reflected in the Odia letters, especially those with sharp curves. The typeface ‘Noto Sans Odia’ illustrates some of these.

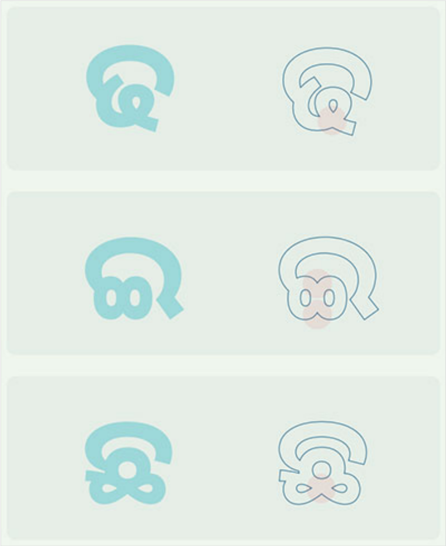

Figure 4.3.r
Source: Amit Patjoshi

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4.4 Muller Lyer Illusion

Between the 'A' and 'B' line segments seen below, which one would you say is longer than the other?

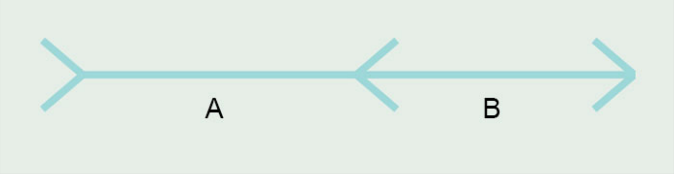

Figure 4.4.a
Source: Amit Patjoshi

Most people would be quick to say that A is the longer segment and B is the shorter segment. Would you believe me if I said these line segments are equally spaced? These line segments are of the same length, and it is due to the Muller Lyre illusion that one looks longer than the other. What is the Muller Lyer illusion? And how does this illusion influence the way we perceive different objects?

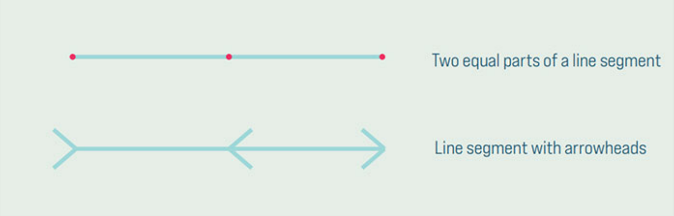
Two equal parts of a line segment
Line segment with arrowheads

Figure 4.4.b
Source: Amit Patjoshi

The Müller-Lyer illusion is an optical illusion that illustrates the change in perceived sizes of objects when they interact with other elements. The Müller-Lyer illusion is commonly recognized as two parallel lines, one of which terminates with inward-pointing arrows and the other with outward-pointing arrows. The one with the inward-pointing arrows appears to be substantially longer than the other. The Müller-Lyer illusion (1889) is named after Franz Carl Müller-Lyer, a German psychiatrist and sociologist.

How does the Muller Lyer illusion work?

There is no obvious explanation for why the Müller-Lyer illusion occurs, yet a few theories have tried to explain the phenomenon over time.

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Visual Perception for Communication Designers

Human Factors and Sociotechnical Systems Studios
by
Vivek Kant and Sruthi Sridhar
IDC, IIT Bombay

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The first theory is called the centroid theory. The theory states that the perceived length of an object is determined by the position of the object's centroid.

As seen in the picture below, the points of the arrowheads are changed into arcs. The centroids of these arcs are then indicated using points. As seen on the left, the outward-facing arrowheads will have their centroids closer together than the inward-facing arrowheads on the right. Therefore, the line between the outward-facing arrowheads will be considered shorter as the distance between their centroids is also shorter.

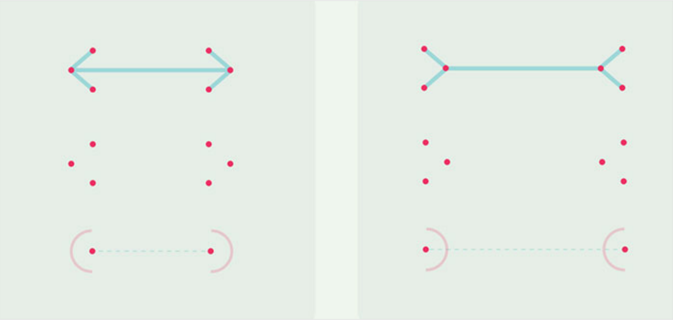

Figure 4.4.c
Source: Amit Patjoshi

Another prominent theory is the "eye movement theory," which claims that humans see one line as longer than another because viewing a line with inside pointing arrows requires more eye movements than viewing a line with outward-pointing arrows. This theory is usually ignored as the illusion occurs without eye movement.

Another popular explanation is the "assimilation theory," which claims that we see one line as longer because our visual system cannot split the figure into parts. The line with inward-pointing arrows is, in fact, longer as a whole figure. However, this notion is often dismissed.

The perspective explanation is one of the most popular. We often use angles to evaluate depth and distance in the three-dimensional world. We've grown accustomed to seeing corners everywhere since we live in a "carpentered world." The brain is habituated to seeing such angles, interpreting them as distant and near corners, and making size judgments based on this information. When the brain sees the Müller-Lyer arrows, it interprets them as far and near corners, overriding retinal input that both lines are the same length.

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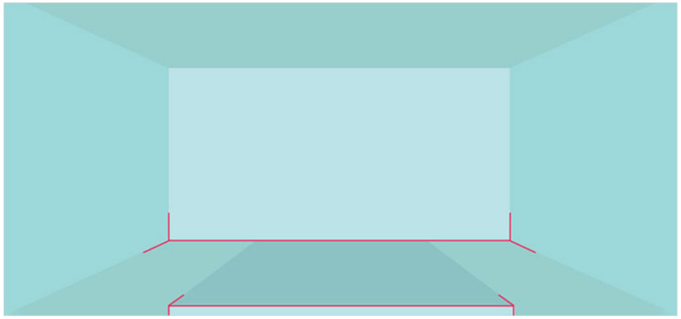

Figure 4.4.d
Source: Amit Patjoshi

A perspective view of a room could be an excellent way to explain this. The "angles out" configuration correlates to a faraway item, such as the concave corner of a room, whereas the "angles in" configuration refer to a closer object.

The angles formed by the lines in the Müller-Lyer illusion are frequently processed as depth cues, as we do in perspective, resulting in a change in perceived size.

The illusion persists even when the arrows are swapped with circles, which have nothing to do with perspective or corners and appear to refute the perspective hypothesis.

Which leads to the next question, how does this illusion work with other shapes? And how does this influence our perception of the size of different shapes?

Basic two-dimensional objects such as squares, triangles and circles can also be misinterpreted when viewed together due to the Muller-Lyer illusion. For example, in the image below, even though the three shapes' height and diameter are identical, there is a difference in our perception of their sizes. When viewed together, the circle looks smaller than the triangle, which looks smaller than the square.

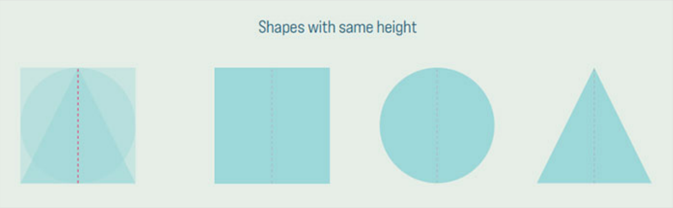

Figure 4.4.e
Source: Amit Patjoshi

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The circle and triangle have been slightly enlarged to compensate for the illusion, resulting in an optically corrected image that makes the triangle, square, and circle appear to be of identical size.

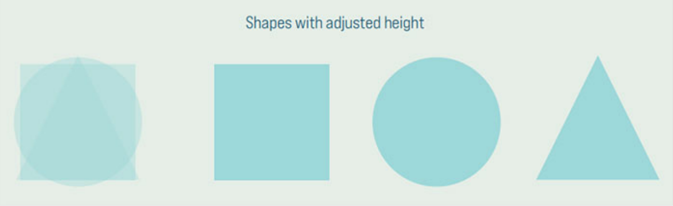

Figure 4.4.f
Source: Amit Patjoshi

How does this difference impact our perception of fonts?

Typefaces, particularly those in the Latin alphabet, are generally derivatives of the basic shapes. Therefore, they can be associated/categorized using them. As shown below, the letters, like the shapes, are susceptible to illusion. The cap height at the top and the baseline at the bottom bind the uppercase of the typefaces. Even if the letters were made identical using mathematics and were contained between the baseline and the cap height, some letters will still appear smaller than others. Just like the shapes above, some letters are intentionally made larger to make us perceive them as the same size.

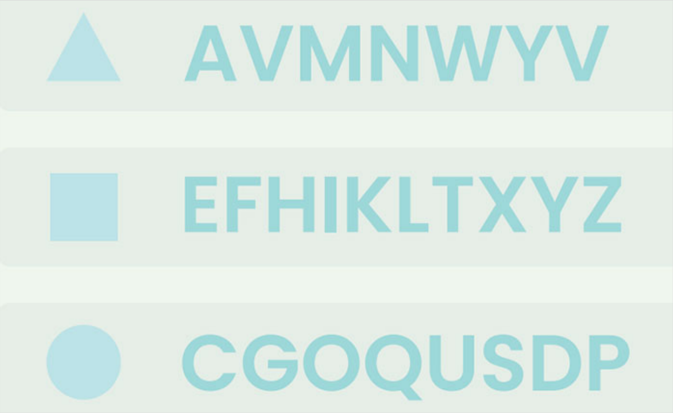

Figure 4.4.g
Source: Amit Patjoshi

Overshoots are the parts of the letters that extend above or below the cap height or baseline. These overshoots exist because they are parts of the letters with characteristics similar to those of triangles or circles at the end.

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Some letters are considered smaller due to their interaction with horizontal lines when forming a word. When letters are curved at the top and bottom, such as the letters' O' or 'C,' there is very little interaction of the surface at the top and bottom, but flat letters, such as the letters' H' or 'F,' have a lot of interaction with the horizontal line.

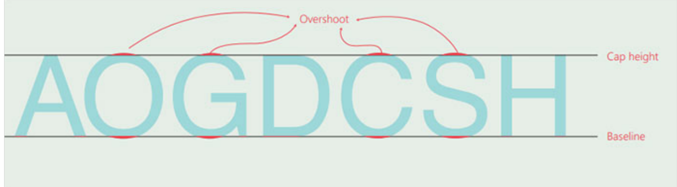

Figure 4.4.h
Source: Amit Patjoshi

Does this occur with other scripts?

The illusion can occur in any script based on how these letters are created as it's inherent to the shapes. The image below, for example, depicts some of the letters in Odia font. The optical corrections performed to counter the illusion are indicated in red. Because most Odia letters are curved, the total size difference in Odia scripts is minimal compared to Latin scripts.

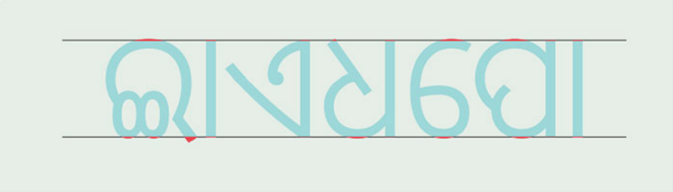

Figure 4.4.i
Source: Amit Patjoshi

As depicted in the following figure, the Devanagari scripts have a horizontal line called "Shirorekha" on top of them to 'complete' the word. Therefore, only the part of the letter on the baseline has to be adjusted to counter the illusion.

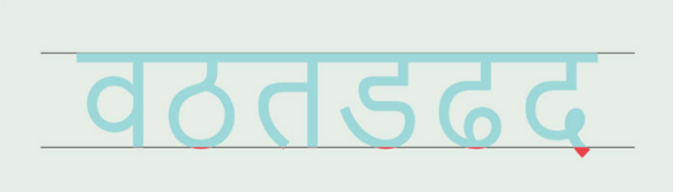

Figure 4.4.j
Source: Amit Patjoshi

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Does changing the width axis impact the perception of the sizes of these letters?

Uppercase letters’ C’ and ‘O’ were written in Acumin font using the same font size but varying widths. The image below shows that the degree of overshoot reduces as the font width decreases. This is because the letters’ relative widths are smaller than their lengths, giving them a shape similar to a rectangle. Therefore, they interact more with the horizontal lines at the top and bottom of the letter than their wider counterparts do.

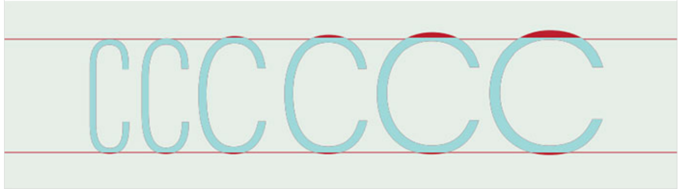

Figure 4.4.k
Source: Amit Patjoshi

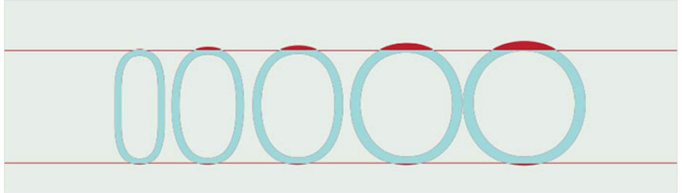

Figure 4.4.l
Source: Amit Patjoshi

Although there appears to be a difference in the cap height of the broader letters, this impact is best seen in the form of a word.

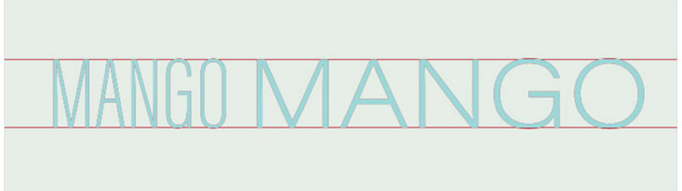

Figure 4.4.m
Source: Amit Patjoshi

Does the weight of the font also have a similar influence on our perception?

Unlike the width axis, the overshoot does not vary when the letter weight is adjusted while the width remains constant.

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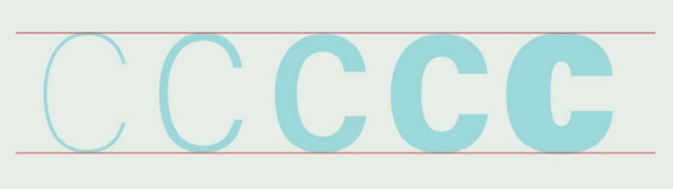

Figure 4.4.n
Source: Amit Patjoshi

This is true even for the Odia letters, two of which are shown in the sample below with weight variations.

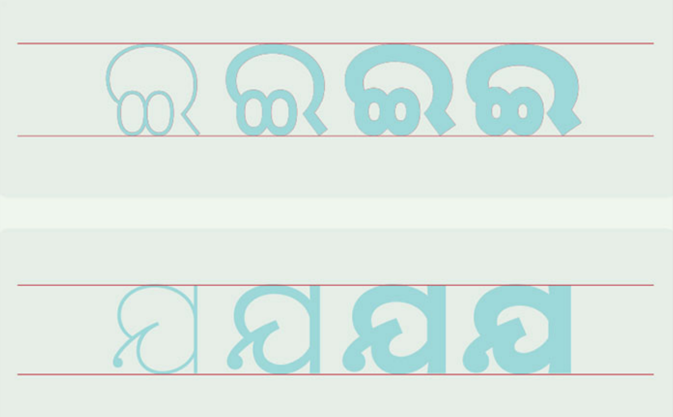

Figure 4.4.o
Source: Amit Patjoshi

Their terminals would likewise determine the letters’ height. For example, ‘Futura’ has pointed to ‘A’ and ‘V’ terminals, whereas Acumin has a flat terminal. The pointed terminals are positioned beyond the baseline/cap height to make the letters look as if they have a similar height.

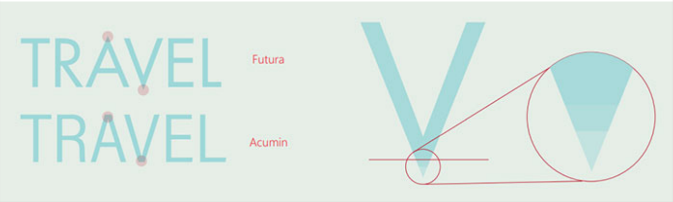

Figure 4.4.p
Source: Amit Patjoshi

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4.5 Bulging Checkerboard

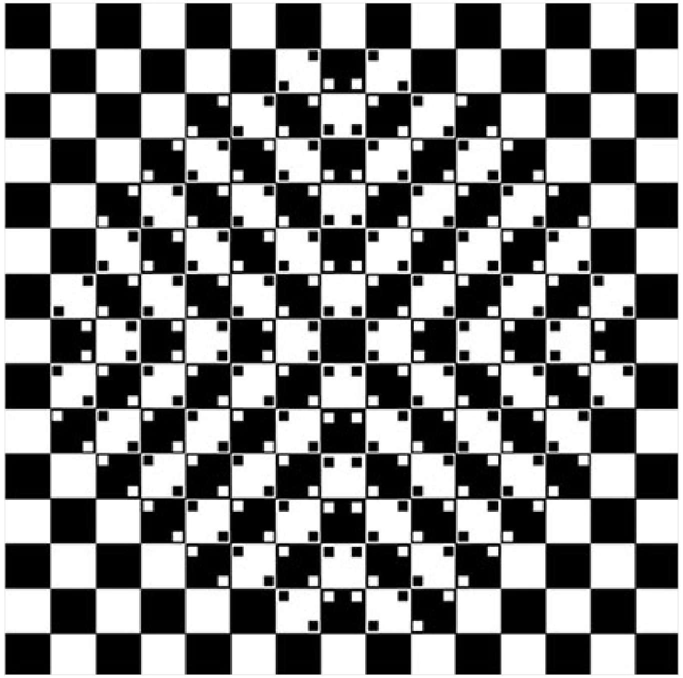

Figure 4.5.a
Source: Akshata Kare (Recreated for academic purpose)

Does the checkerboard look like it is bulging from the middle? This is known as the bulging checkerboard illusion. Akiyoshi Kitaoka created the optical illusion known as The Artifact. The checkerboard, in this instance, appears to swell from the centre, but it is actually just a conventional checkerboard with tiny squares placed at specific intervals to create the illusion.

Why does this illusion take place? Because this uses the Gestalt law of closure, we tend to draw connections between the lines and perceive the squares as off-centre. If we were to see the squares individually, they would appear to be a standard squares, but when we view them collectively, our brains classify them as quadrilaterals, creating the illusion of a "Bulging Checkerboard."

Another explanation provided by the creators is we tend to perceive lines wherever possible. Take a look at the diagram below. This represents two tiles that are connected in the illusion.

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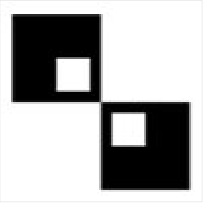

Figure 4.5.b
Source: Akshata Kare

However, the interpretation of what we consider the edges of the black square is based on the edges of the white square; therefore, there is a slight misalignment. In the diagram below, the misalignment is shown as the orange lines.

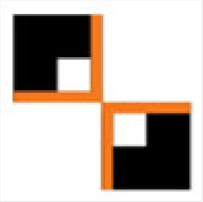

Figure 4.5.c
Source: Akshata Kare

And as the perceived lines are not "straight," we perceive the squares to be slightly tilted.

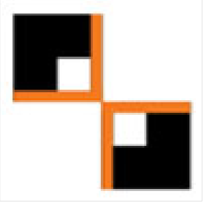

Figure 4.5.d
Source: Akshata Kare

In each quadrant, this tilt is manipulated by positing the white dots slightly different in us perceiving the board as bulging.

We can use this perceived tilt to our advantage by carefully arranging these tiny compartments throughout the checkerboard to produce illusions like the bulging checkerboard.

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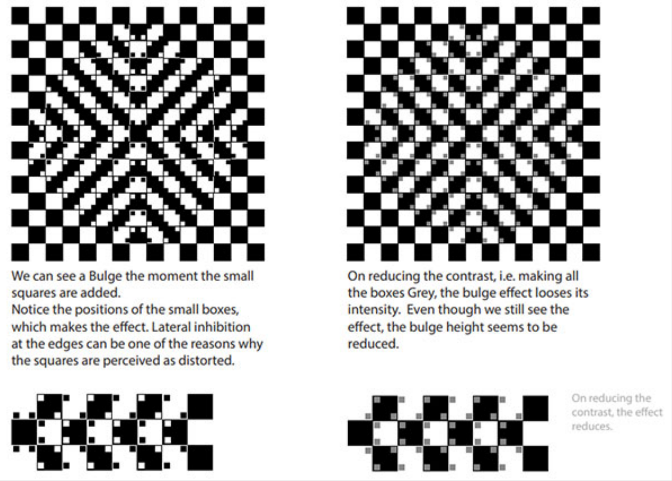
Here are more explorations:

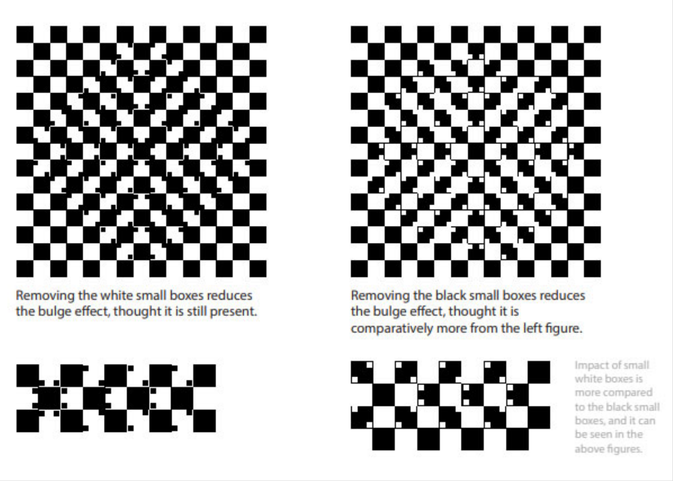


We can see a Bulge the moment the small squares are added.
Notice the positions of the small boxes, which makes the effect. Lateral inhibition at the edges can be one of the reasons why the squares are perceived as distorted.

On reducing the contrast, i.e. making all the boxes Grey, the bulge effect looses its intensity. Even though we still see the effect, the bulge height seems to be reduced.

On reducing the contrast, the effect reduces.

Figure 4.5.e
Source: Akshata Kare

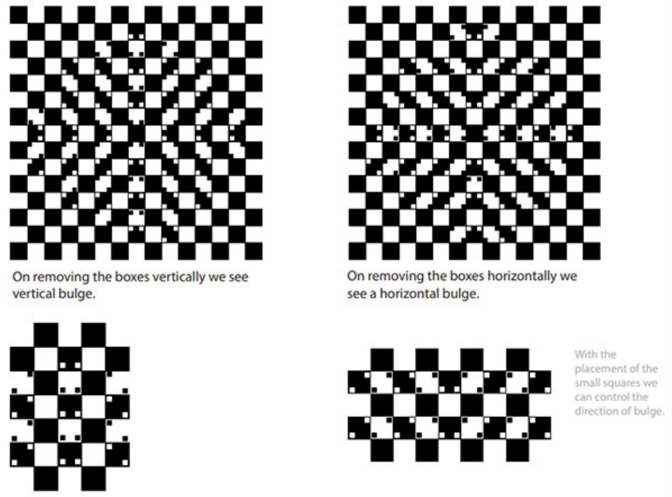


Removing the white small boxes reduces the bulge effect, thought it is still present.

Removing the black small boxes reduces the bulge effect, thought it is comparatively more from the left figure.

Impact of small white boxes is more compared to the black small boxes, and it can be seen in the above figures.

Figure 4.5.f
Source: Akshata Kare

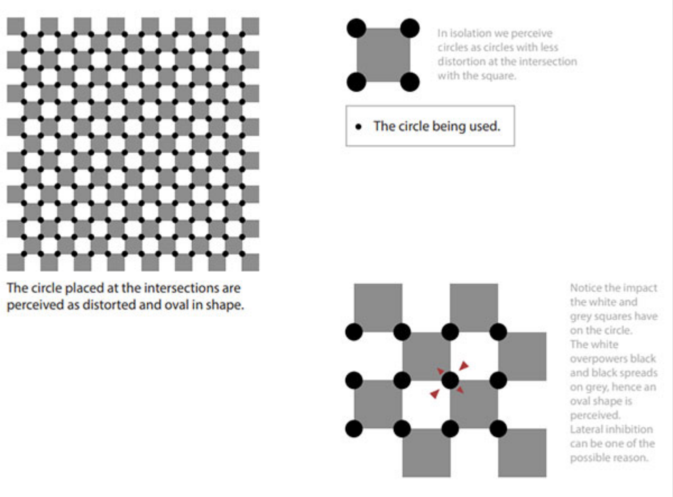


On removing the boxes vertically we see vertical bulge.

On removing the boxes horizontally we see a horizontal bulge.

With the placement of the small squares we can control the direction of bulge.

Figure 4.5.g
Source: Akshata Kare



In isolation we perceive circles as circles with less distortion at the intersection with the square.

- The circle being used.

The circle placed at the intersections are perceived as distorted and oval in shape.

Notice the impact the white and grey squares have on the circle.
The white overpowers black and black spreads on grey, hence an oval shape is perceived.
Lateral inhibition can be one of the possible reason.

Figure 4.5.h
Source: Akshata Kare

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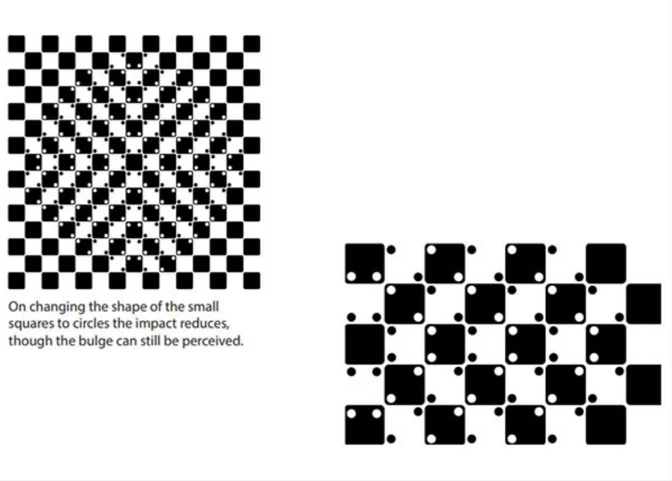
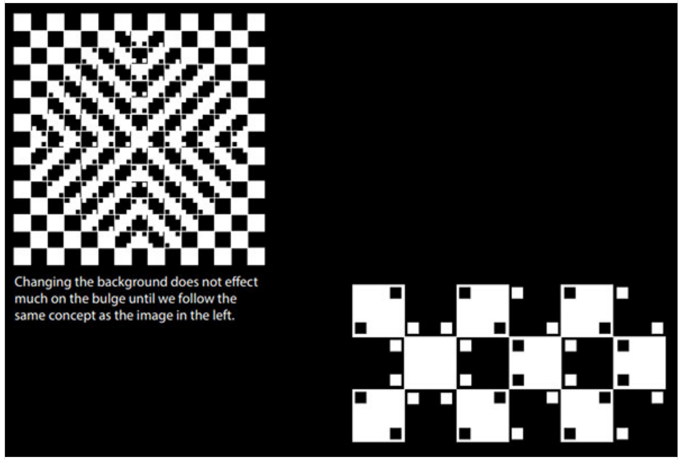


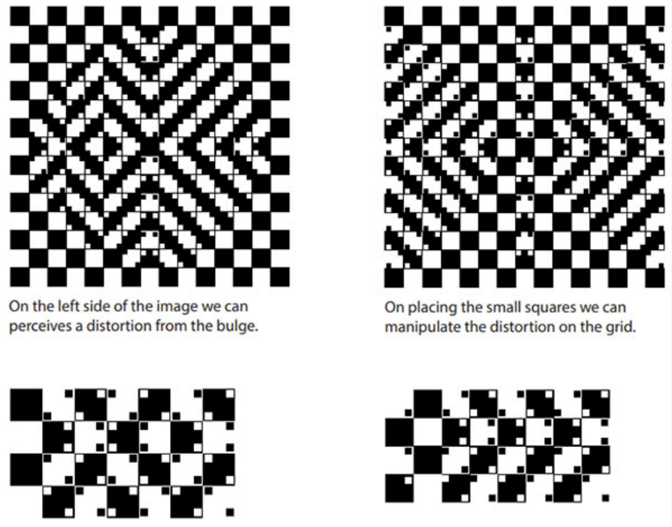
On changing the shape of the small squares to circles the impact reduces, though the bulge can still be perceived.

Figure 4.5.i
Source: Akshata Kare



Changing the background does not effect much on the bulge until we follow the same concept as the image in the left.

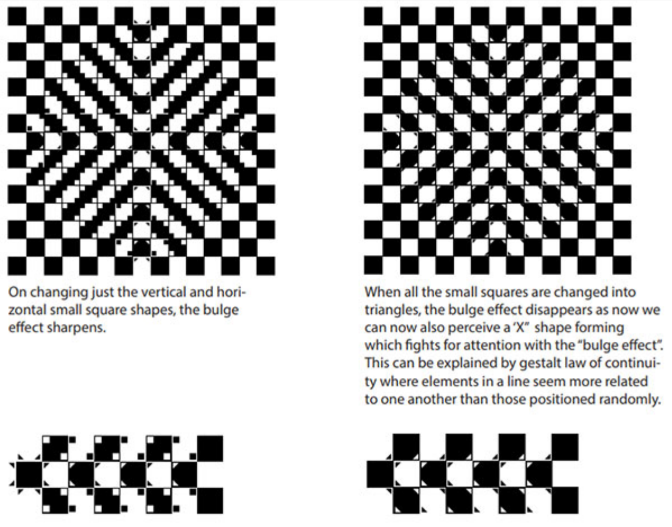
Figure 4.5.j
Source: Akshata Kare



On the left side of the image we can perceives a distortion from the bulge.

On placing the small squares we can manipulate the distortion on the grid.

Figure 4.5.k
Source: Akshata Kare



On changing just the vertical and horizontal small square shapes, the bulge effect sharpens.

When all the small squares are changed into triangles, the bulge effect disappears as now we can now also perceive a 'X' shape forming which fights for attention with the "bulge effect". This can be explained by gestalt law of continuity where elements in a line seem more related to one another than those positioned randomly.

Figure 4.5.l
Source: Akshata Kare

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Visual Perception for Communication Designers

Human Factors and Sociotechnical Systems Studios
by
Vivek Kant and Sruthi Sridhar
IDC, IIT Bombay

Source:
https://www.dsource.in/course/visual-perception-communication-designers/4-edges-lines-and-angles/45-bulging-checkerboard

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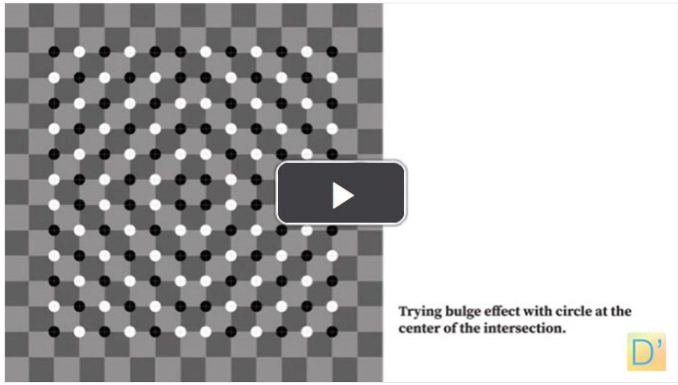
Here is a video investigating further explorations of the illusion:


Trying bulge effect with circle at the center of the intersection.
D'

Source: Akshata Kare

For more explorations and explanations, take a look at the pdf below:
- Bulging Checkerboard......

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4.6 Herings Illusion

The German scientist Ewald Hering first observed this geometrical-optical illusion in 1861, which seems like two parallel straight lines bending outward. Based on the scientific basis of his times, Hering explained the phenomenon as the result of our minds exaggerating the angle formed at the spots where the red and radiating lines cross. In actuality, this illusion, like many others, has various explanations.

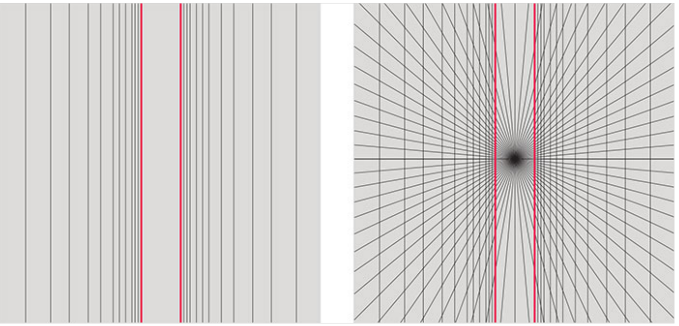

Figure 4.6.a
Source: Nidhin Joseph

For example, some data suggest that after the mind has recognized particular traits in a stimulus, it goes one step further and imagines those traits to exist more substantially than they actually do. This hypothesis contends that when two patterns are observed simultaneously, the weaker pattern's perception is warped to preserve an exaggerated view of the stronger one. Hering's figure offers a stronger pattern and is perceived as having more spread than it actually does; the mind must distort the parallel lines to preserve this perception.

Additionally, according to researcher Mark Changizi, it has to do with people's tendency to anticipate the near future visually (Changizi et al., 2008). Changizi believes that the human visual system has evolved to account for the neurological delay by creating representations of what will happen one-tenth of a second from the moment that light reaches the retina to the time the brain receives that light. Other explanations could account for the edge-based interactions of the vanishing point. In the pictures below, various elements of Hering's illusion have been explored by varying some elements. Hering's illusion will help the visual designers understand how perspectives and lines interact with each other.

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Here are some more explorations of the Hering's illusion.

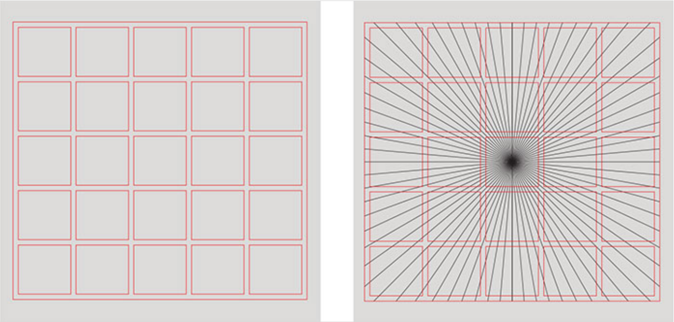

Figure 4.6.b
Source: Nidhin Joseph

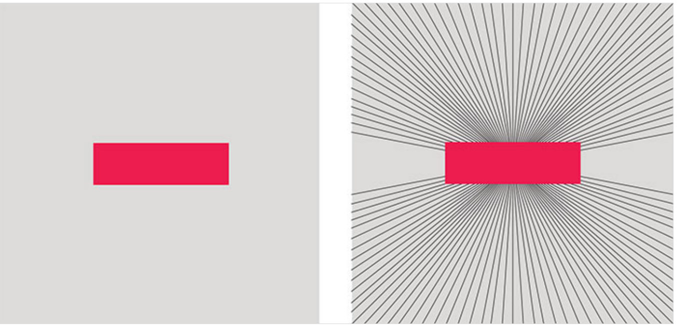

Figure 4.6.c
Source: Nidhin Joseph

For further explanation about the explorations, please look at the link below.

- Herings Illusion......

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4.7 Orbison Illusion

The Orbison illusion is an example of an illusion in which the context causes a geometric figure's actual shape to appear distorted. When the figure is overlaid on a field of crossing lines, its shape seems warped. The Orbison illusion is named after psychologist William Orbison, who initially reported his findings in a 1939 article. The Orbison figures typically feature a figure overlaid on a background of radial or concentric lines. Because of the background image, the figure looks distorted; squares bulge, and circles frequently look elliptical. The Orbison illusion falls in the same class of illusions as Hering's illusion.

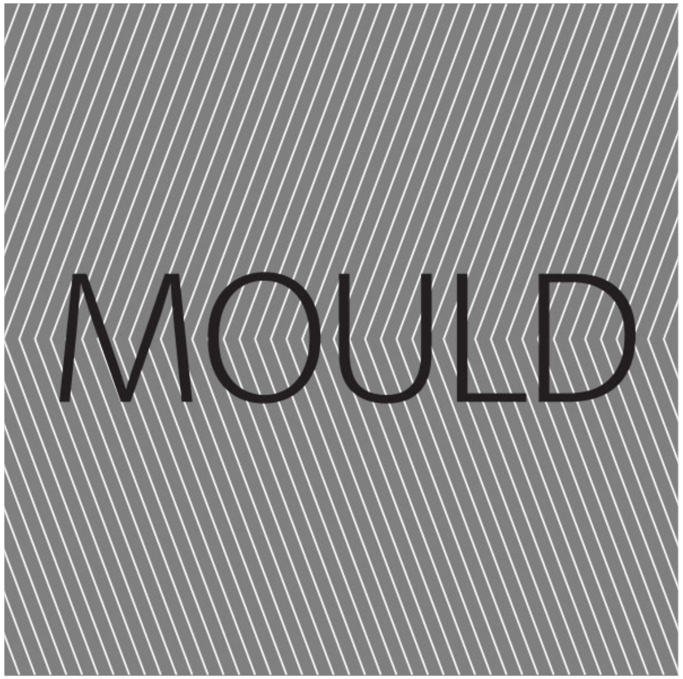

Figure 4.7.a
Source: Jinal Shah

Currently, it is still unclear how this illusion takes place. Orbison originally proposed that these illusions were caused by fields of force formed during the perception of the background patterns. Any line that crossed these fields would experience a predictable distortion afterwards. However, according to recent findings, there is little evidence to support this notion. The Orbison illusion will greatly help communication designers understand how the background field interacts with the sides of the objects placed in it, such as in experimental or expressive typography.

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Here are some more explorations of the Orbison illusion.

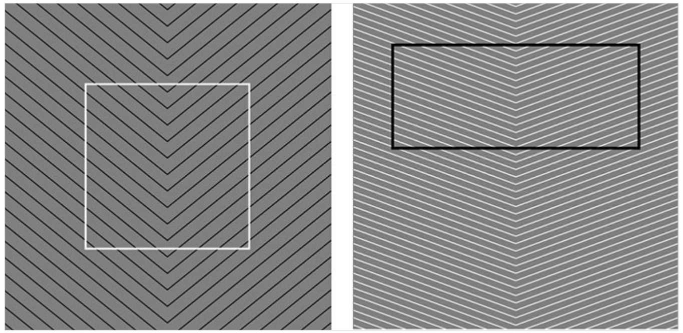

Figure 4.7.b
Source: Jinal Shah

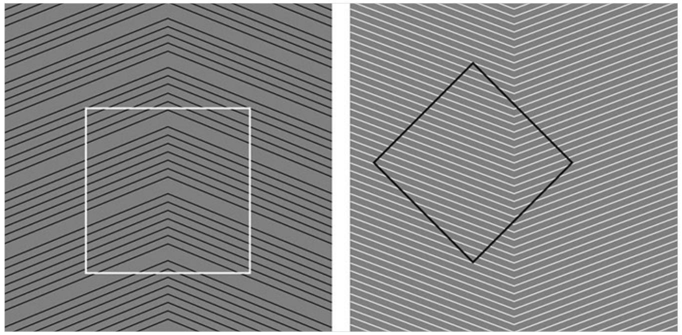

Figure 4.7.c
Source: Jinal Shah

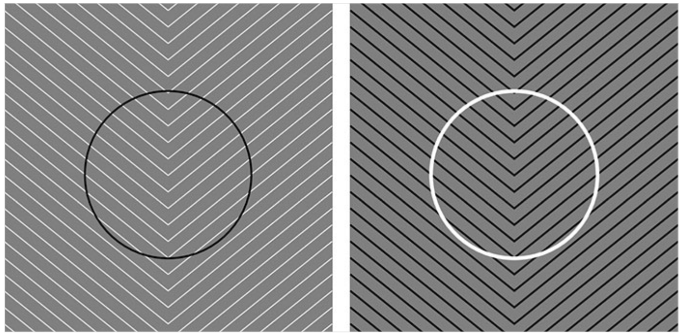

Figure 4.7.d
Source: Jinal Shah

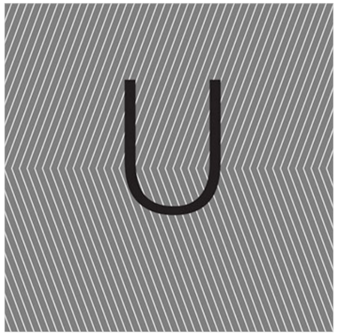

Figure 4.7.e
Source: Jinal Shah

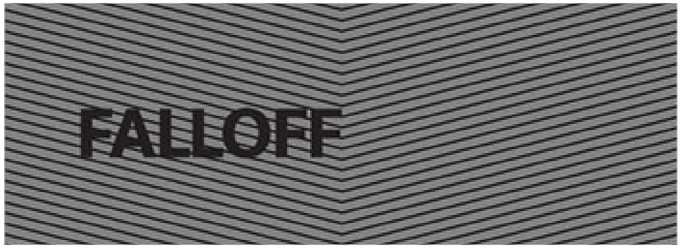

Figure: 4.7.f
Source: Jinal Shah

Please look at the pdf below to learn more about these explorations and the Orbison illusion:

- Orbison Illusion......

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4.8 Zollner illusion

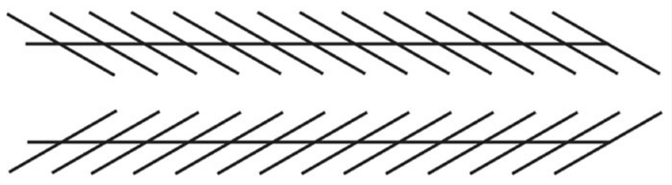

Figure 4.8.a
Source: Sanskruti Landage

Do these lines look straight? Do the two lines look parallel to you? Like most people, you would say no. They are not parallel. However, look at Figure 3.2.8.b; these lines are parallel. This is the Zöllner illusion. It is a well-known optical illusion in which parallel lines appear distorted due to the pattern on them or around them. The original illusion constitutes a series of short vertical or diagonal lines intersecting several parallel lines. The parallel lines seem to converge or diverge from one another due to the intersection. The illusion was discovered in 1860 by Johann Karl Friedrich Zöllner. The Zöllner Illusion is one of many illusions in which a central feature of a basic line, such as the length, straightness, or parallelism of lines, looks warped as a result of other elements of the image, such as background or foreground lines, or other intersecting forms.

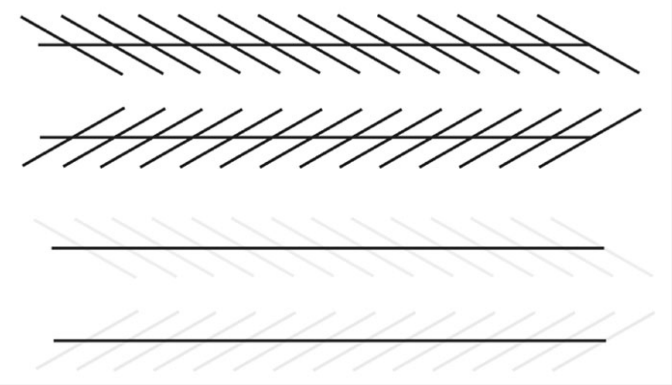

Figure 4.8.b
Source: Sanskruti Landage

How does this illusion work?

Scientists still don't fully understand the specific mechanisms behind the Zöllner illusion, but it's plausible that the way the brain interprets angles and oblique lines may be the basis for this illusion.

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According to this notion, the brain overestimates acute angles while underestimating obtuse angles. The brain then changes the transverse lines' angles to give the appearance that the lengthier lines are slanted.

A variation of the Zöllner illusion in which the long lines are substituted with dots plotted along the same path, which reduces the illusory effect, as seen below, is one piece of evidence that might support the acute-angle expansion idea (the image is adapted from Westheimer, 2008)

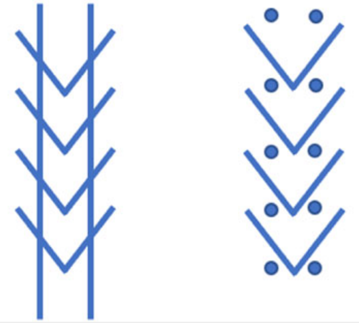

Figure 4.8.c
Source: Sruthi Sridhar

A sense of depth could also bring on the illusion. It may be due to the perception of the longer lines as being closer to the viewer than the other shorter lines, which the angle of the shorter line may bring on.

Here are some explorations of the Zöllner illusion.

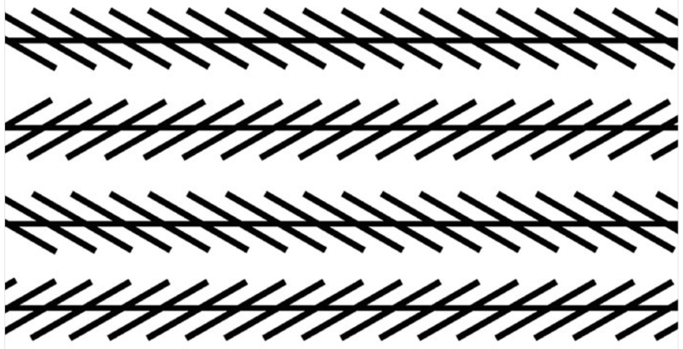

Figure 4.8.d
Source: Sanskruti Landage

In Figure 4.8.d, we can see some cross-hatching enhancing the illusion.

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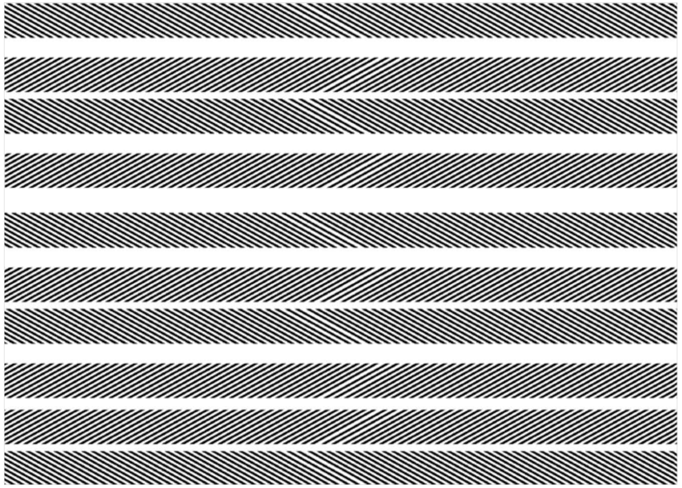

Figure 4.8.e
Source: Sanskruti Landage

In Figure 4.8.e, we can see that the effect is strong as the white areas in the middle seems non-parallel to one another.

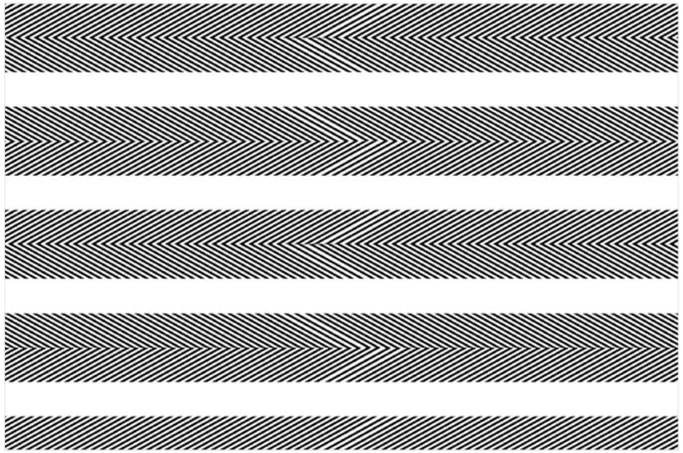

Figure 4.8.f
Source: Sanskruti Landage

In Figure 4.8.f, the lines have been stacked together. As the distance between the stacks increase, the illusion gets stronger. As one can see, the strength of the illusion is not dependent on the longitudinal orientation of the stacks; rather, what enhances the illusion is that the stacks are oriented orthogonally.

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Moreover, in the exploration above, the direction the lines point in makes a difference. The opposite-facing lines have a bulging effect, adding to the illusion.

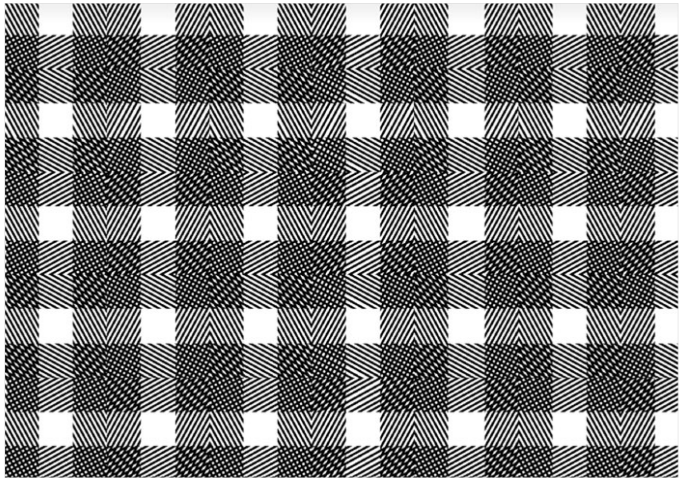

Figure 4.8.g
Source: Sanskruti Landage

We can see that in Figure 4.8.g, the stacks have been laid out in a lattice formation. Previous research suggests the stronger illusion is not because the stacks have been rotated but rather because the stacks have been laid on top of one another, which has a "shear deformation" effect. This effect makes us think the stack's segments slide over one another or that they stretch the stack perpendicular to the segments, enhancing the illusion.

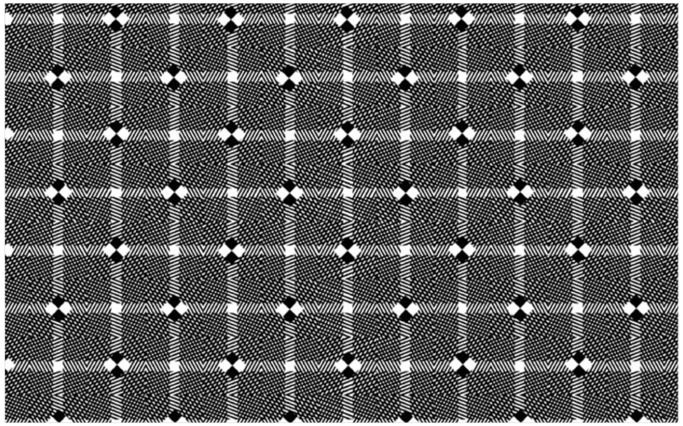

Figure 4.8.h
Source: Sanskruti Landage

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In Figure 4.8.h, focus on the diamond closer to the centre to see the big picture (inspired by the Hermann Grid/ Scintillating Grid Illusion). The Zöllner “blocks” laid in the background affect the perception of the “straightness” of the white lines. Even though the white lines are straight and perpendicular, they cannot be perceived as such. The intricate grid and the diamonds between them intensify the illusion and confuse the eye.

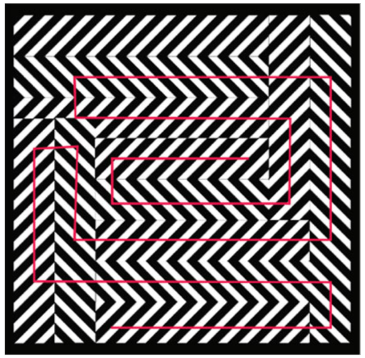

Figure 4.8.i
Source: Nidhin Joseph

The combination of background herringbone pattern where it facilitates the acute angles expansion makes it have a distorted maze line which is, in reality, straight lines. One will be unable to perceive parallel lines accurately due to the interference of the background.

The following figures simultaneously explore elements of three illusions together. Specifically, they combine the features of Zöllner, Hering and Ouchi illusion. These include the angled orthogonal pattern in the background that distorts our perception of two parallel lines as non-parallel from the Zöllner illusion. The background plays a vital role in our perception of the triangle/square’s features from the Hering illusion. Finally, from the Ouchi illusion, the triangle/square in the middle makes it seem like the illusion is moving.

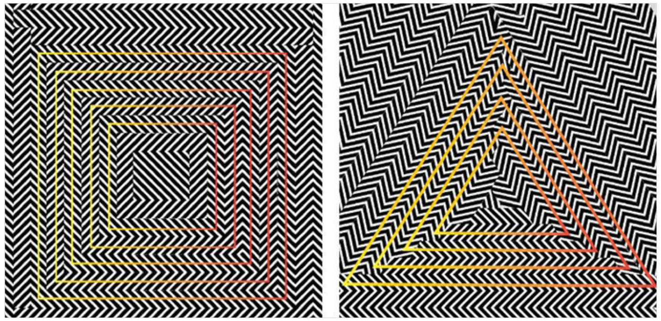

Figure 4.8.j, k
Source: Nidhin Joseph

The two explorations below (Figure 4.8.j, 4.8.k) are a clear depiction of the distortion of line characters due to the effect of underlying line or pattern characters.

In Figure 4.8.j, the square seems distorted due to the same angular expansion, and the play of colour adds more insight. Colours with more brightness and saturation may have a higher distortion value than the low bright colour tones.

In Figure 4.8.k, also the line distortion takes place, and in a macro level perception, the triangular shaper foreground has a lesser distortion than that of a concentric square line distortion.

Source:
https://www.dsource.in/course/visual-perception-communication-designers/4-edges-lines-and-angles/48-zollner-illusion

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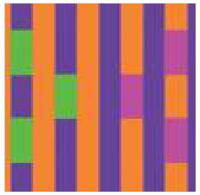
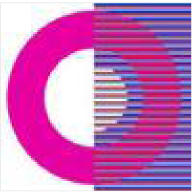
5. Color and Lightness

5.1 Lightness Constancy

5.2 Lightning Checkerboard



5.3 Simultaneous Contrast



5.4 Colour Assimilation

5.5 Watercolour Illusion

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5.1 Lightness Constancy

A fundamental phenomenon of visual perception is the idea of constancies. The mind and brain perceive issues as constant, despite things changing in everyday life. How is this possible? The mind perceives some constancies: shape constancy, color constancy, and brightness constancy.

Shape constancy is one type of perceptual constancy. The critical aspect here is that the mind interprets an object's shape as constant even though its shape changes on the retina and in real life. Therefore, even if a coin is presented at an angle that causes it to appear as an oval on the retina, it is still perceived as a circle.

Another perceptual constancy is the tendency to judge objects as the same size no matter how far away they are from the viewer. So, if a 5-foot-tall item seems very small on the retina, it will be considered quite far away.

Lightness constancy is the third type of perceptual constancy, which is the tendency to perceive an object's perceived lightness as constant even when the light conditions change. If a person wears black pants and a white shirt, the shirt will appear significantly lighter in bright daylight than the pants. However, if the sun is obscured by dense clouds, even though the pants and shirt have less light to reflect, the shirt will appear as bright as before because lightness constancy is at play.

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5.2 Lightning Checkerboard

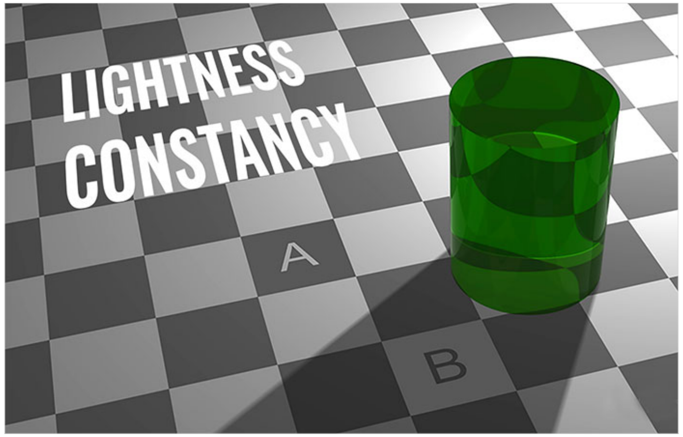

Figure 5.2.a
Source: Urmi Banarjee

The picture above shows a checkered patterned floor with two tiles labelled A and B. We can also see a light source in the top right corner that casts a diagonal shadow of the green translucent cylinder. On its face, the tile labelled B appears to be of a lighter shade of grey than Tile A. However, would you believe me if I said that they are both the same shades of grey

Edward H. Adelson, a professor at the Massachusetts Institute of Technology, first demonstrated this illusion in 1995, making us perceive the same shades of grey as different colors. Why do we then perceive the tiles to be of different shades of grey? Why is it that even after being told they are the same shade of grey, can we not see it in the picture above? This brings us to the larger question: How is our brain making sense of this picture? In addition, as designers, what can we learn from this illusion?

One of the essential overarching explanations is that our brain interprets the above image as three-dimensional. Therefore, our visual system estimates a lighting gradient and uses it to evaluate the floor's characteristics, like lightness, regardless of the shadow. Hence, when asked to assess which tile is lighter, our brain would sensibly judge the item: In the checkerboard arrangement, is it a light or dark tile, regardless of the lighting? The answer would be that tile A is the darker tile, and tile B is the lighter one, making us perceive the tiles as one being darker than the other.

Although this explanation seems plausible, isn't our intuitive explanation for this illusion something along the lines of "maybe we cannot see the difference because tile B is in the shadow whereas tile A is not"?

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Well, we would be somewhat correct! Shadow does play a role in the discrepancy in evaluating the shades of the tiles; however, there is a caveat. The picture above shows that the "shadow" of the cylinder has soft edges, whereas the tiles have sharp edges. We perceive the shadow to be a shadow because of the blurriness of the shadow (faded edges) and the visibility of the item casting the shadow (cylinder). Therefore, our visual system overlooks moderate changes in light level to determine the color of surfaces without being fooled by the shadow and all the attention moves to the sharp edges of the tile. Due to the checkerboard-patterned floor, the edges of the tiles (formed by four abutting tiles) are interpreted as a change in surface color rather than a change in brightness/lighting. Therefore, tiles A and B are interpreted as different colors. Moreover, colors such as grey, yellow, and green are harder for the visual system to judge precisely, and they must rely on the surrounding environmental cues.

In the picture above, we can see that tiles A and B are surrounded by lighter-colored and darker-colored tiles, respectively. Simultaneous lightness and contrast help illustrate the importance of the surrounding environment in visual perception. The simultaneous brightness contrast effect states that a grey patch surrounded by black would seem lighter than a grey patch surrounded by white. In other words, the perceived lightness of a tile will be based on the perceived lightness of surrounding tiles. In the case of tile B, it will be perceived as lighter because there is a lot of "black" adjacent to the grey patch. Tile A will be perceived to be darker because a lot of white surrounds the grey tile. Regardless of the shadow, the lightness contrast explains the environmental influence on why we perceive the two tiles as different colors.

The lighting checkerboard illusions can reveal the nature of lightness computation in the human visual system. Artists can also use observers' nuanced perceptions to create specific lighting effects in their works. Graphic designers can comprehend how these various lightness effects can be used subtly in their creations to provide a holistic experience.

For more about the illusion, please look at the pdf below:
- Lightning Checkerboard......

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5.3 Simultaneous Contrast

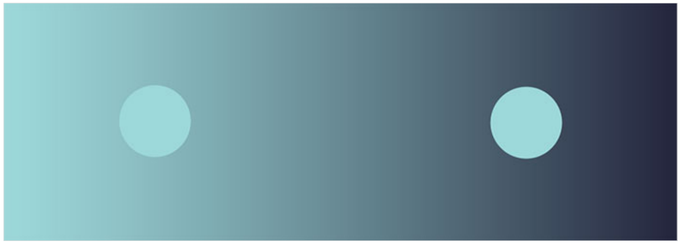

Figure 5.3.a
Source: Amit Patjoshi

Do you see a difference in the colors of the two circles above? If you are like most people, you would say that the circle on the left is lighter than the circle on the right. Would you believe me if I said the circles are identical? Both the circles seen on top are identical. However, due to the background, one looks lighter than the other. This is called the simultaneous contrast effect.

Simultaneous contrast is a phenomenon that occurs when two adjacent colors interact and alter our perception, making them more or less saturated or more or less bright than one another. It can be seen in a variety of hues and luminosities. When two patches of equal luminance appear on contrasting backgrounds, the phenomenon of simultaneous brightness contrast occurs. The patch against the lighter backdrop appears darker, whereas the patch against the darker background appears lighter. Also, and this is critical, this is a phenomenon that can only be assessed by comparison. This is true for all types of perception phenomena. We have no way of knowing or defining how cold an item is or how saturated a color is. We can only state that something is cooler or more saturated than something else.

Michel Eugene Chevreul, a French chemist, first developed the phrase "simultaneous contrast effect" in 1839. Chevreul made his discovery after receiving complaints about color inconsistencies in tapestry fibres. He was surprised to discover that the color discrepancies were not due to dye faults but were due to the placement of colors on different backgrounds. Chevreul found that when two samples of identical fibres were placed on different backdrops, they looked to be different colors. He discovered that a patch of non-hue grey appeared lighter when set on a black background, as opposed to when placed on a white background, it appeared darker. He labelled this phenomenon the simultaneous contrast effect.

When two circles of the same color, A777B7 with brightness level 70, are put on a continuous gradient with brightness levels ranging from 86 to 23 from left to right, the circle on the right appears brighter, and the circle on the left seems darker. The phenomenon occurs because the circles are influenced by their respective lighter or darker background, making us perceive them differently.

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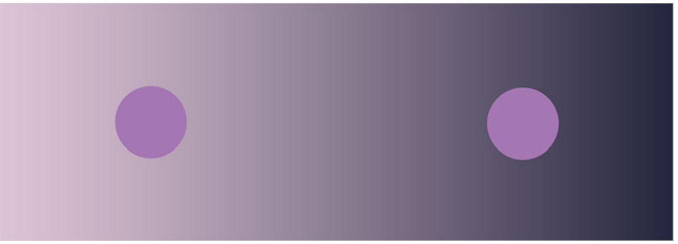

Figure 5.3.b
Source: Amit Patjoshi

The concept of belongingness regulates our perception of brightness. The theory asserts that the appearance of a region is determined by the portion of the environment to which it belongs. According to this theory, as the circle (left) looks to be resting on a lighter background, the background will influence our perception of it. Similarly, because the circle on the right appears to be resting on a darker background, the background will influence our impression of the circle. Moreover, the lighter region makes the left circle appear darker, while the dark background makes the right circle appear lighter.

The image below depicts six different rectangles, each with a brightness ranging from 100% to 0%. Circles of the same colour and brightness (FFBA44, with a brightness of 80) are inscribed within rectangles. As the brightness of the rectangles decreases, the circle appears lighter.

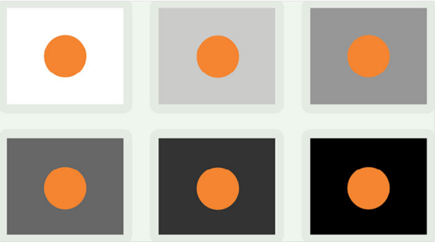

Figure 5.3.c
Source: Amit Patjoshi

Initially, explorations only witnessed the illusion while using shades of black and white (white illusion, Mach band etc.). However, the idea that different colours also interact, causing our perceptions to alter and produce the simultaneous contrast effect, was soon explored. As we rarely see colours in isolation, our perception of the colour is influenced by simultaneous contrast present in the environment. Its effect is based on the complementary colour law, which states that any pure colour physiologically necessitates its counterpart hue or complement colour. Therefore, if the complementary colour is not present, the eye is prone to perceive it simultaneously. For instance, the greens and magentas used in the image below are of the same brightness, but they seem different because of the backgrounds they are put on.

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by
Vivek Kant and Sruthi Sridhar
IDC, IIT Bombay

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https://www.dsource.in/course/visual-perception-communication-designers/5-color-and-lightness/53-simultaneous-contrast

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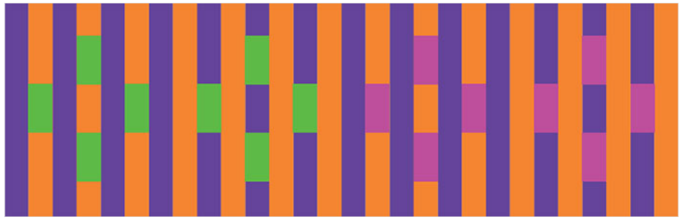

Figure 5.3.d
Source: Amit Patjoshi

Moreover, when Chevreul placed a patch of non-hue grey on a green background, it appeared to be somewhat red, and when positioned on a red background, it appeared to be slightly green. This type of contrast can be seen in the exploration below, where when a green rectangle is placed in a red background, it is much brighter and vice versa. The simultaneous contrast causes visual strain at the intersection of the hues, as shown in the diagram below. This causes the figure to vibrate where the two colours meet.

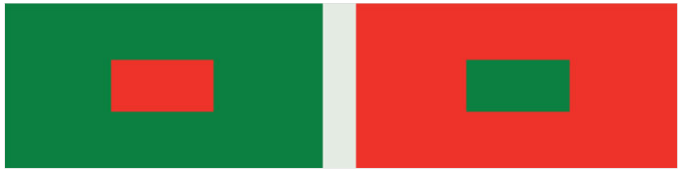

Figure 5.3.e
Source: Amit Patjoshi

If simultaneous contrast is not considered when designing presentations, it can hurt letter legibility. For example, the figure below created a sample text on the same background with identical attributes. However, one sample text used contrasting red as the font colour while the other used a tinted version of the green. As it can be seen, the contrasting text colour on the left reduces legibility and makes it exceedingly difficult to read, but the text is easier to see when tinted.

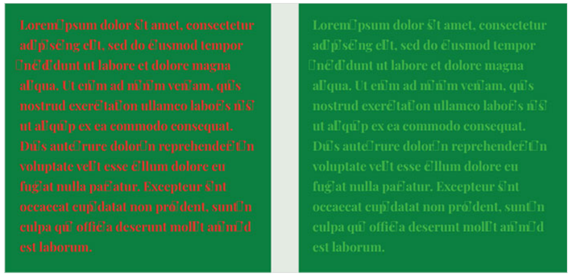

Figure 5.3.f
Source: Amit Patjoshi

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The legibility is increased when a shade of red that is not as contrasting is placed over the green background. The tint of red reduces the impact to some extent, but the effect persists. However, when a similar colour or shade of green is used, the effect is further diminished and, at times, becomes almost non-existent.

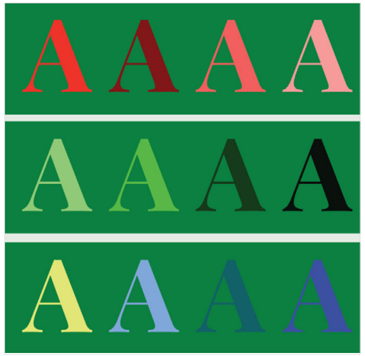

Figure 5.3.g
Source: Amit Patjoshi

Does the effect exist with Odia's script?

The Odia letters, like other forms, can be affected by the simultaneous contrast effect. For instance, a set of Odia letters were placed on a background of alternating purple and orange stripes. The same set of letters was then relocated to the strip on the right in the bottom row. The letters appear differently in each stripe which can be attributed to the simultaneous contrast effect.

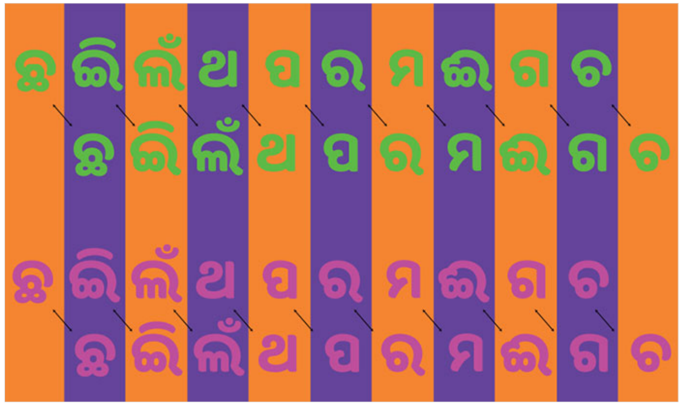

Figure 5.3.h
Source: Amit Patjoshi

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Several open and closed spaces in the Odia script could potentially contribute to the simultaneous contrast effect. If the internal colours of closed letters, such as the letter 'Pa,' are modified, the effectiveness of the colour of the letter can either diminish or enhance.

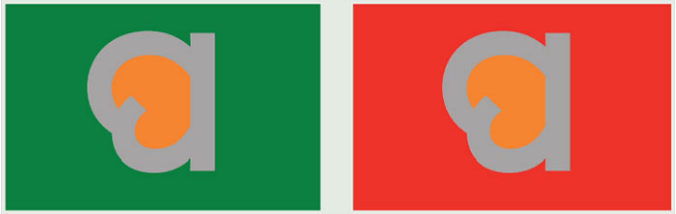

Figure 5.3.i
Source: Amit Patjoshi

This is also true when the backdrop is kept the same, but the internal colours in the characters are changed.

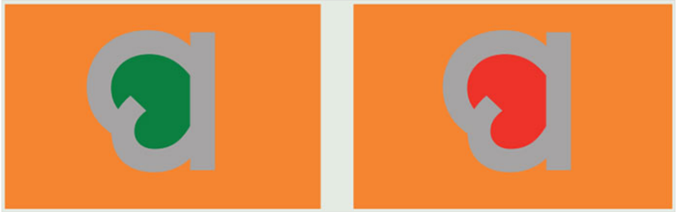

Figure 5.3.j
Source: Amit Patjoshi

The effect is also apparent when the background is pixelated with similar colours. The difference in grey becomes more apparent in the pixelated background compared to the solid background. When the colour-generating pixels are of optimum size, it can also indicate that the effect will have a greater impact on the text in the event of smaller font sizes on the screen. This can be seen in the exploration below with the second-row vs the third-row.

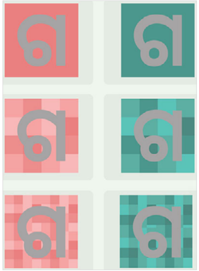

Figure 5.3.k
Source: Amit Patjoshi

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When the screen is glossy and viewed in a bright area, screen glare can also distort the perceived colour of the letter, similar to pixelation.

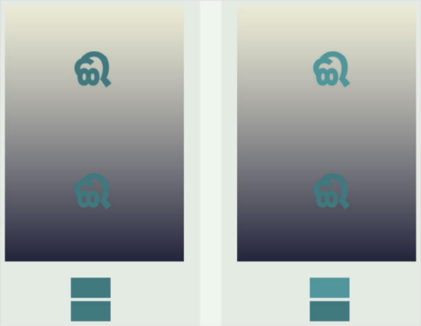

Figure 5.3.l
Source: Amit Patjoshi

The impact is also apparent when the letters are utilized in gigantic proportions. We may not be able to perceive the letters as a whole when they are viewed at massive sizes. We may see them in pieces, and when we do, the fill colour of these letters will vary depending on the viewing location.
The Odia letters' Ma' and 'Kha' are represented as parts in the figure below. The red appears slightly different in entirely enclosed spaces than in partially enclosed spaces and open spaces.

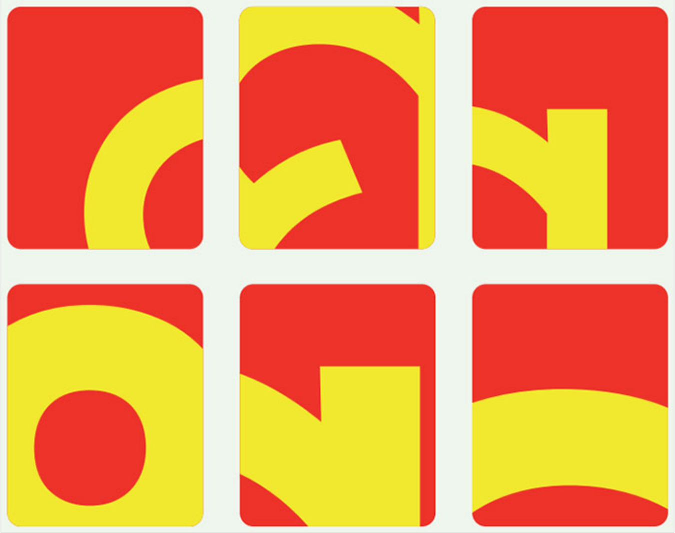

Figure 5.3.m
Source: Amit Patjoshi

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5.4 Colour Assimilation

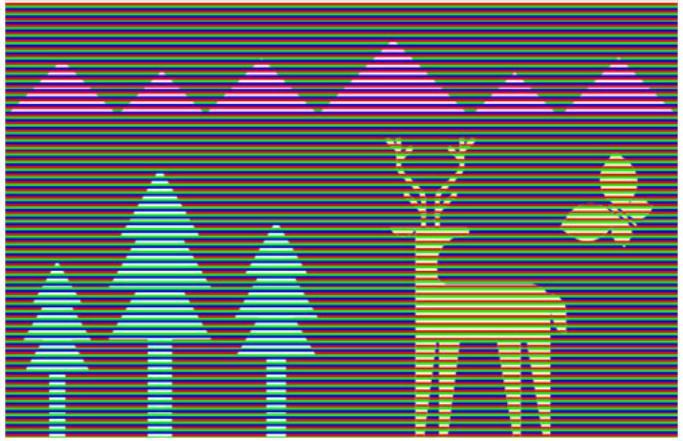

Figure 5.4.a
Source: Sumedh Narnaware

In the picture above, what would you say is the color of the butterfly, mountains, deer, and trees? Well, if you are like most people, the trees would look to be in cyan, the butterfly and deer would look to be in yellow, and the mountains would look to be in magenta. However, what if I told you they were all light yellow in color? That it is an optical illusion known as color assimilation or the Bezold effect.

The “assimilation effect,” also known as the Bezold Effect, is an optical illusion in which the color or colors around it influence the hue or value of a color. Wilhelm von Bezold, a German professor of meteorology, is credited with discovering the Bezold effect. He found that color might seem different depending on its position to neighbouring hues. Bezold learnt that, in some cases, a colored region would take on the same color as its surroundings. This theory contradicts the widely accepted conclusion of “simultaneous color contrast,” in which color takes on the complimentary hue and contrasting brightness of its surroundings.

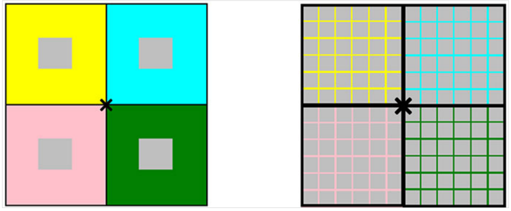

Figure 5.4.b
Source: Sruthi Sridhar. Recreated from Shapiro and Todorović, 2017

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The representation above reveals the difference in simultaneous contrast and color assimilation. The one on the left shows how simultaneous contrast works. The four grey squares seem to be tinted with desaturated hues that complement the colors around them (clockwise from the top left: yellow, cyan, pink, and green). The image on the right displays color assimilation. The overlay grid colors seem to have colored the grey backgrounds. Focusing on the centre cross may enhance the results.

Color assimilation states that depending on the colors around it, a particular hue may appear to shift when observed closely. For instance, a yellow box surrounded by blue will appear darker than one surrounded by red.

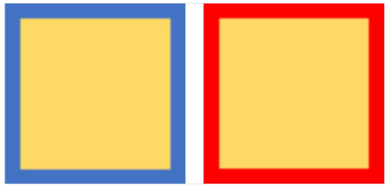

Figure 5.4.c
Source: Sruthi Sridhar

The color surrounded by another hue frequently looks to take on a tint of that color; for example, red boxes bordered by blue will appear bluer than those surrounded by white.

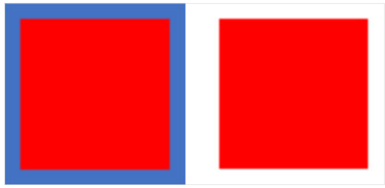

Figure 5.4.d
Source: Sruthi Sridhar

The best example is when thin borders of black and white separate two patches of the same color. Compared to the one surrounded by white, the one encircled by black appears darker. The colored areas absorb the color of their border, which is the opposite of the contrast effect that is frequently seen with hue and brightness.

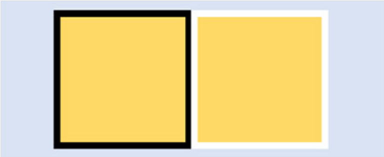

Figure 5.4.e
Source: Sruthi Sridhar

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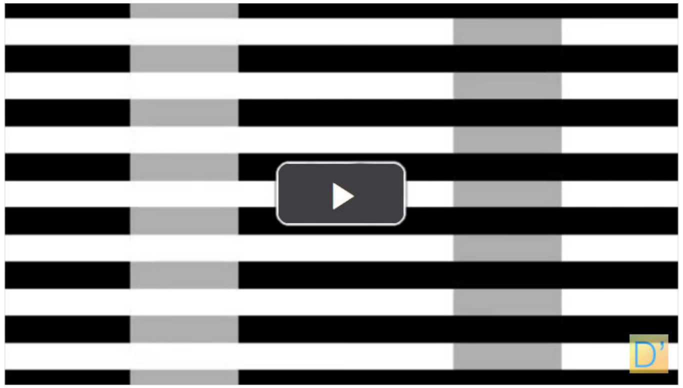
Why does this take place? How does this illusion work? One way to explain the Bezold effect is using White's illusion. White's illusion is often considered the achromatic illustration of color assimilation; the video below illustrates one form of White's illusion.



Source: Kunal Khawaskar

The video above shows that a set of horizontal black and white bars make up White's illusion. Looking at the image, it is clear that the grey bars with white stripes around them are lighter than the grey bars with black stripes. The grey bars bordered by white not only seem lighter but also seem brighter.

An explanation attributed to this is the gestalt law of grouping. The grey patch appears darker on black than when they are present on a white background because it has been "grouped with" that color and vice versa.

Additionally, researchers assert that the T- junction, which they suggest signals depth through occlusion, is the critical grouping component in this situation. Others, on the other hand, support a "scission" explanation of the White effect, in which the T- junction in these displays cause the patches to be divided into several layers. This explanation of the White effect states that the test patch concurrent with the black stripe appears lighter because some of the "blackness" has been attributed to the black bar beneath it and vice versa.

Moreover, the theory of layer decomposition or scission proposes that our visual system breaks down a picture into three layers: reflectance, illumination, and transparency. The T-junctions, created by the intersections of the ends of the objects with the two grating phases, enable a perceptual scission process that treats the object stripes as if they were a thin, translucent veil covering the grating bars.

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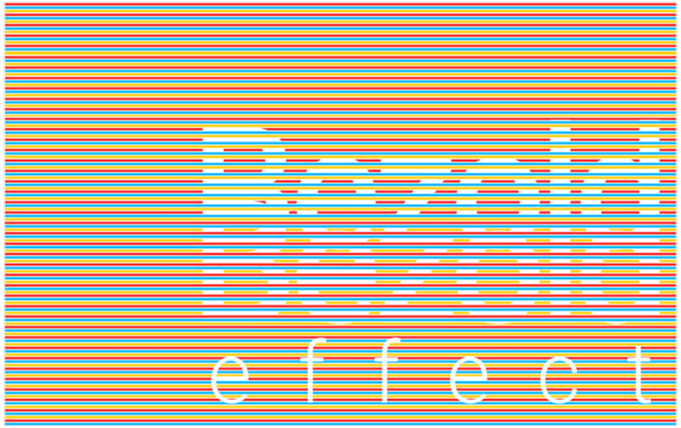

Figure 5.4.f
Source: Madhuri Suresh

For example, in the picture above, we see two rows of the word "bezold." The actual color of the font is white, however, the one on the top is perceived to be yellow, and the bottom one is considered red. According to the decomposition theory, the yellow color of the "bezold" is "split" into two elements blue+yellow and red. The red becomes the stripes that run continuously underneath the letters, and the blue+yellow becomes the veil that covers the word.

Similarly, the second "bezold" word appears red due to yellow stripes running continuously underneath and the red+blue strips forming the veil which covers the entire word. The words appear yellow and red, respectively, because they are defined by the veil created by the process of scission.

Here is another exploration of the Bezold effect. The figure below shows a simplistic version of a landscape. The sun is grey, and the mountains are green in color.

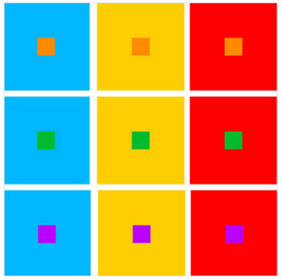

Figure 5.4.g
Source: Madhuri Suresh

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However, the perceived color changes when a set of primary color stripes are introduced over the picture. Bezold effect is of great interest to graphic designers to study the assimilation of colors in their everyday work.

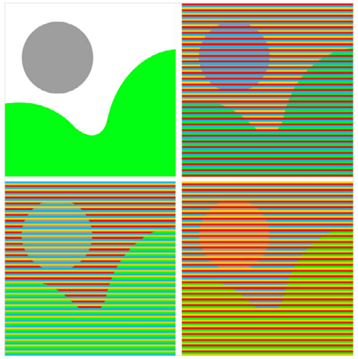

Figure 5.4.h
Source: Madhuri Suresh

Here are more explorations of the Bezold effect:

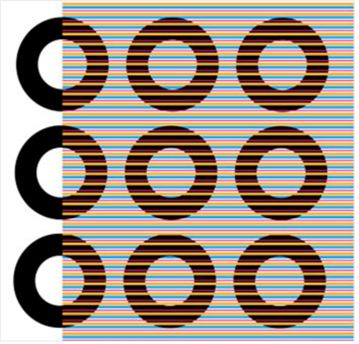

Figure 5.4.h
Source: Madhuri Suresh

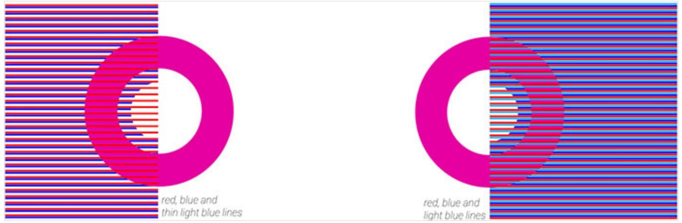

Figure 5.4.j
Source: Madhuri Suresh

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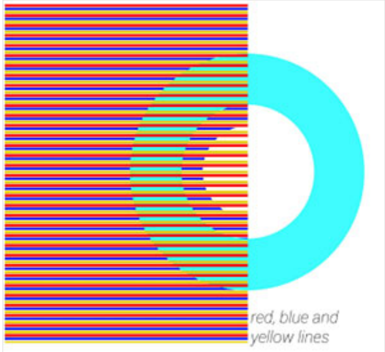


Figure 5.4.k
Source: Madhuri Suresh

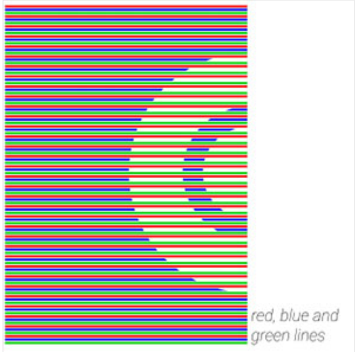
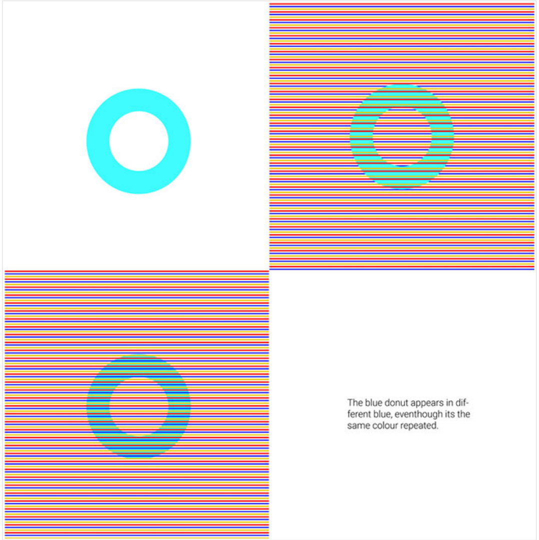


Figure 5.4.l
Source: Madhuri Suresh



The blue donut appears in different blue, eventhough its the same colour repeated.

Figure 5.4.m
Source: Madhuri Suresh

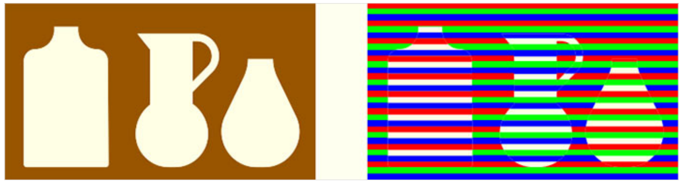


Figure 5.4.n
Source: Sumedh Narnaware

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Visual Perception for Communication Designers

Human Factors and Sociotechnical Systems Studios
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Vivek Kant and Sruthi Sridhar
IDC, IIT Bombay

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5.5 Watercolour Illusion

What colour are these stars?

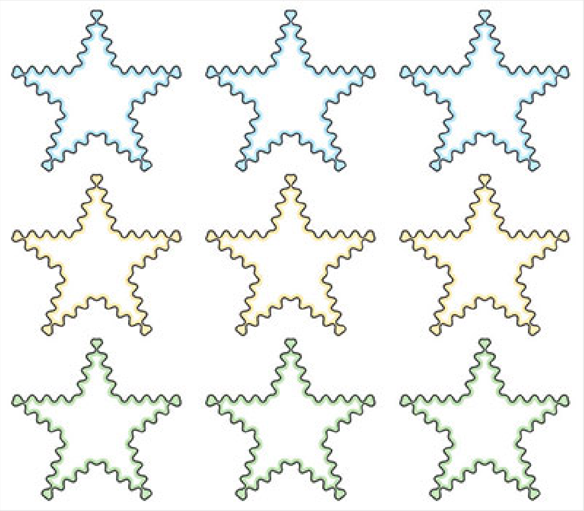

Figure 5.5.a
Source: Shraddha Prabhu

The first, second, and third rows of stars appear to be filled with blue, yellow, and green colours, respectively. But what if I told you that they are entirely white inside? That they only appear to be filled in with colour? This is known as the watercolour illusion. When a pale bright colour is placed on either side of a dark contour, the brighter colour expands into the surrounding white region, creating a watercolour effect.

Baingio Pinna first described this illusion in 1987. The watercolour illusion displays two main phenomena. The first is a distinct coloration effect, or a long-range assimilative spread of colour, which originates from a thin coloured outline that is juxtaposed to a darker coloured outline. Second, a potent figural effect, or figure-ground segregations, over a substantial area.

How does this illusion work?

Our mind considers the darker hue to be separating the figure from the background. The darker colour (black) is regarded as the border, and the lighter colour is perceived as the filling colour. Since the inner border is lighter in colour here, the colour appears to be spreading inwards. The lighter-coloured (blue, yellow, or green) line that surrounds the darker border and the actual colour of the figure (white) are both recognized as the filling.

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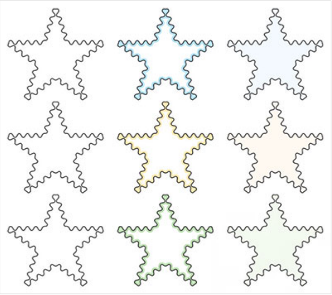

Figure 5.5.b
Source: Shraddha Prabhu

The entire area inside the stars (stars on the right) appears to have a faint tint of the respective hues when the light-coloured lines are flanked by the black outlines of the stars (stars on the left). The stars appear to be covered in light colours as a result of the white background and coloured outline combination.

What enhances or diminishes the illusion?

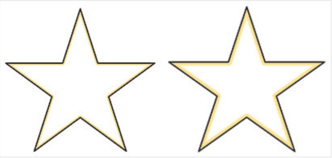

Figure 5.5.c
Source: Shraddha Prabhu

The watercolour look is diminished when the black outline is thicker. We are unable to see the yellow line accurately due to increased contrast. Increasing the yellow line’s thickness also lessens the watercolour effect since our brain now perceives the yellow line as a distinct, thicker line within the border.

What if one reversed the order and the black line was inside the shape and not outside?

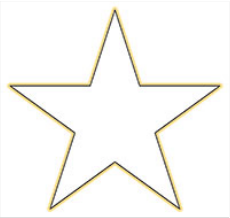

Figure 5.5.d
Source: Shraddha Prabhu

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The watercolour effect is reversed when the black and yellow lines are switched. The yellow colour seems to be expanding at this point. However, this is not very effective.

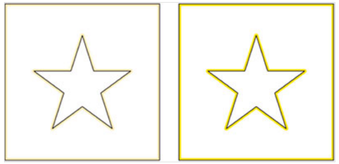

Figure 5.5.e
Source: Shraddha Prabhu

The watercolour effect is enhanced by enclosing the same star in a black square with a yellow border surrounded inside, which also yields a “keyhole” effect. The hole appears to be three-dimensional, and the boundary defines a region. Now, the perception of figure and ground is flipped. The figure at the front is seen as a square with a star-shaped hole, while the background is considered as the area inside the star. A stronger keyhole can be seen as the yellow lines’ brightness increases.

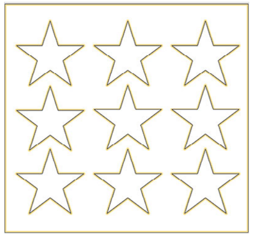

Figure 5.5.f
Source: Shraddha Prabhu

The watercolour effect persists even when there are several objects present. The area where the colour spreads is perceived as the figure. The pale-yellow square with several star-shaped holes is now considered the figure, with a white background.

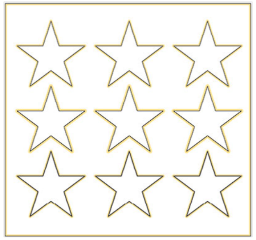

Figure 5.5.g
Source: Shraddha Prabhu

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A stronger keyhole may be seen by thickening the yellow line in the second row, while a weaker one can be seen by thickening the black line in the third row.

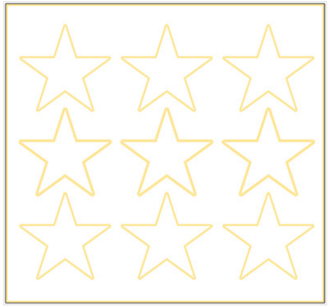

Figure 5.5.h
Source: Shraddha Prabhu

The watercolour and the keyhole appearance are eliminated when the black outline is removed.

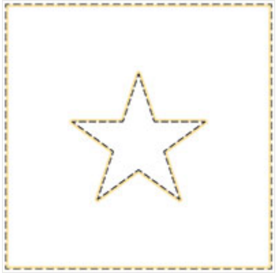

Figure 5.5.i
Source: Shraddha Prabhu

Even with dashed or dotted outlines, the watercolour effect still exists, though it is not as noticeable.

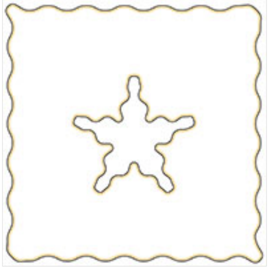

Figure 5.5.j
Source: Shraddha Prabhu

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Wavy lines seem to increase the effect compared to straight lines.

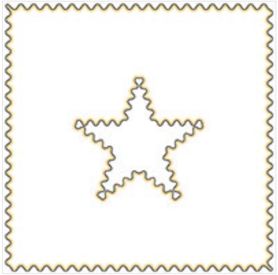

Figure 5.5.k
Source: Shraddha Prabhu

The watercolour effect gets more robust as the "waviness" increases. It appears that the spreading is nearly uniform.

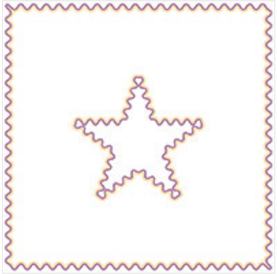

Figure 5.5.l
Source: Shraddha Prabhu

The colour spreading occurs in any combination of dark and light-coloured outlines.

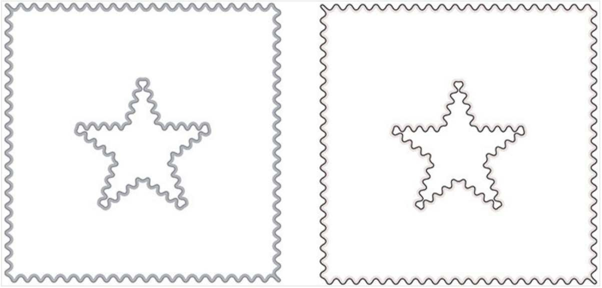

Figure 5.5.m
Source: Shraddha Prabhu

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But one might diminish the watercolour effect by using various shades of the same colour, which results in our brain trying to combine them into a single outline. The higher the contrast between two colours, the stronger the watercolour illusion.

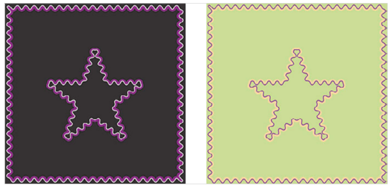

Figure 5.5.n
Source: Shraddha Prabhu

The effect also appears on backdrops with various colours. Compared to the background, the line with higher contrast is seen as the border, whereas the line with lower contrast seems to spread in. However, the colour filling, in this case, is minimal. Therefore, it is best to have a white background.

What if there are two colours bordering a black outline?

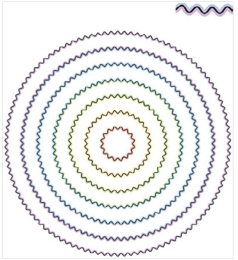

Figure 5.5.o
Source: Shraddha Prabhu

Here, the watercolour effect is faint due to the two contrasting colours surrounding the same black outline.

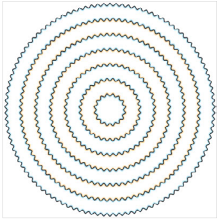

Figure 5.5.p
Source: Shraddha Prabhu

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The watercolour effect is improved by pairing two contrasting colours with a single black outline. They now resemble alternating blue and orange concentric rings.

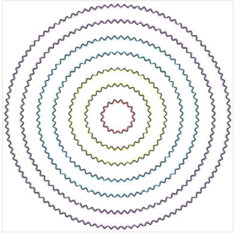

Figure 5.5.q
Source: Shraddha Prabhu

However, the best result is when only one colour is flanked against the black outline.

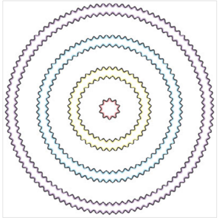

Figure 5.5.r
Source: Shraddha Prabhu

The watercolour effect is more pronounced when the lines of similar colours are placed in proximity. It is congruent with Gestalt's law of proximity.

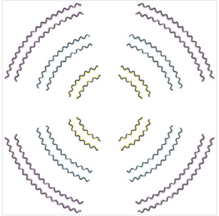

Figure 5.5.s
Source: Shraddha Prabhu

Albeit minimally, even if the outline is not a closed loop, the watercolour effect still persists. This is congruent with the Gestalt law of closure.

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Can the effect take place with letterforms?

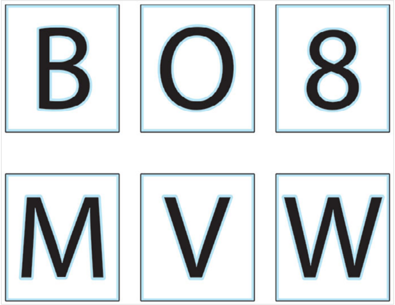

Figure 5.5.t
Source: Shraddha Prabhu

Whether or not they have closed counters, the letterforms inside the black borders with the blue lines flanking them also exhibit the watercolour effect.

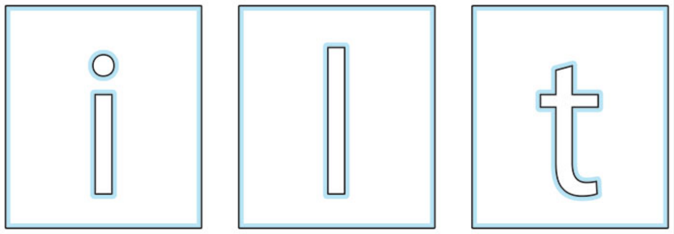

Figure 5.5.u
Source: Shraddha Prabhu

The letterforms' outlines alone can produce a keyhole impression. In this instance, the figures are seen as rectangles with letter-shaped cuts in the front.

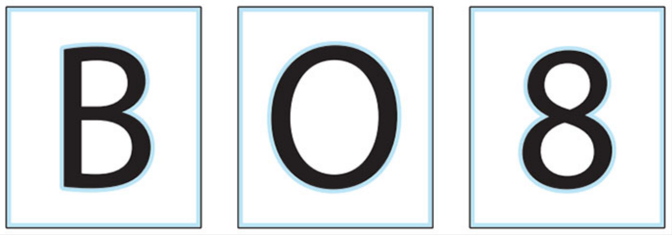

Figure 5.5.v
Source: Shraddha Prabhu

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When the inner skirting of the blue line is removed from letterforms with closed counters, the keyhole effect results, however, in this case, letterforms and rectangles are considered figures and are seen as being in the front.

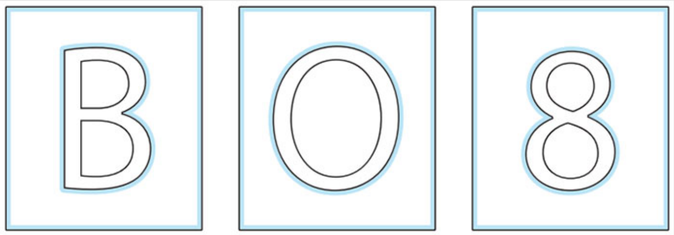

Figure 5.5.w
Source: Shraddha Prabhu

The letterforms' outlines alone can also produce a keyhole appearance. However, it's not entirely evident in this instance whether the letterforms are a part of the ground or figure.

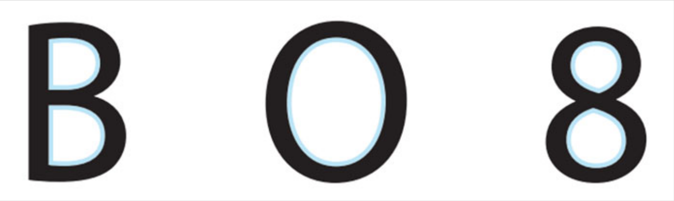

Figure 5.5.x
Source: Shraddha Prabhu

The watercolour effect is also achieved by removing the blue line's outside flanks along with the rectangle, giving the letters the appearance of being completely covered in a light blue tint.

How can designers use the insights from the watercolour illusion?
Designers can use it in maps to make discretely coloured areas separating distinct locations. Posters and other print media can use them to create the illusion of an entirely colourful space with a minimal number of colours. It can also help be time efficient in digital rendering. By using fewer colours, it may be possible to reduce rendering time.

Here is the pdf exploring this phenomenon:
- Watercolour Illusion......

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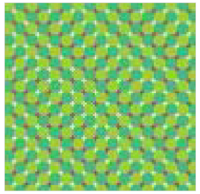
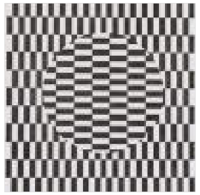
6. Illusory Motion

6.1 Perception of Illusory Motion

6.2 Movement and Motion in Static Images



6.3 Primrose Illusion



6.4 Ouchi Illusion

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6.1 Perception of Illusory Motion

Perception of motion is described as the perception of a sequence of changes. The capacity to detect motion is irrefutably advantageous for survival as it is closely tied to the perception of food and threat. The ability to perceive motion is so fundamental that it seems to come naturally to humans and other organisms. We sense motion when something travels across our field of vision. Unique physical structures have evolved in humans to help with the experience of motion. Your eye muscles, for instance, enable you to move your eyes swiftly and smoothly in all directions. Your head has a roughly 180° range of motion. By moving only your head and eyes, you can physically observe objects throughout a 360-degree field using these structures.

The image of an object moves across successive sites in the retina as it moves across your field of vision, and the experience of motion results from a pattern of successive cell stimulation. To keep a moving object in focus, one has to move their head and eyes; while doing so, there is a feedback system that alerts the brain of the head and eye movements.

An object's actual motion is known as real motion. For example, when a car passes by or a bug crawl across a table. However, numerous techniques exist for creating the perception of motion from a stimulus that is not moving. Illusory motion is the term used for perceiving motion when none exists. Apparent motion is the most well-known and researched sort of illusory motion. For example, look at the video below; it seems like the square is moving towards the right. However, they are two stationary objects.

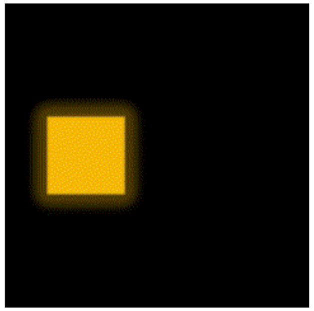

Figure 6.1.a
Source: Sruthi Sridhar

Max Wertheimer demonstrated that when two stimuli at slightly different places are alternated with the proper timing, an observer will interpret one stimulus as smoothly transitioning between the two sites.

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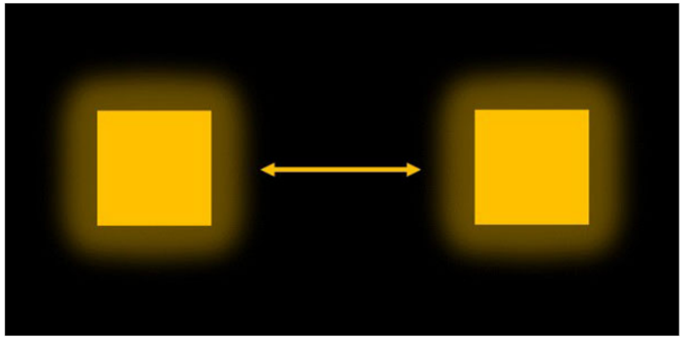

Figure 6.1.b
Source: Sruthi Sridhar. Recreated from Goldstein, 2010

Since there is no actual (or true) motion between the stimuli, this perception is known as apparent motion. This is the basis for the motion in entertainment and advertising-related moving signs, television, and movies.

There are two types of illusory motion: induced motion and motion aftereffects. Induced motion is the phenomenon that occurs when an object moves (the larger one), making one perceive that the smaller stationary object is also moving. The moon, for instance, always appears motionless in the sky. However, the moon may appear to be racing through the clouds on a windy night. In this instance, the smaller, stationary moon seems to move because of the movement of the larger object (movement of the clouds covering a larger region). When someone watches moving stimuli for a long time and subsequently focuses on a stationary object, they experience the motion aftereffect. The object will seem to move in the opposite direction from the moving stimuli.

Some stationary and repeated patterns create the illusion of motion. You can usually enhance the illusion by moving your eyes around the figure. The illusion tends to fade away or even totally vanish if you keep your eyes motionless. For instance, the "snakes" in Akiyoshi Kitaoka's Rotating Snakes illusion seem to be rotating when in reality, except for your eyes, nothing is moving. The animation will slow down or even halt if you focus on one of the black dots in the centre of each "snake."
(See illusion here: http://www.ritsumei.ac.jp/~akitaoka/index-e.html).

Design Course

Visual Perception for Communication Designers

Human Factors and Sociotechnical Systems Studios
by
Vivek Kant and Sruthi Sridhar
IDC, IIT Bombay

Source:
https://www.dsource.in/course/visual-perception-communication-designers/6-illusory-motion/62-movement-and-motion-static

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6.2 Movement and Motion in Static Images

How images move across the retina in our eyes determines how motion is perceived. We perceive motion in an object when it moves into our field of vision. The ability to sense movement depends on whether the spectator is stationary or moving. For instance, a person standing by the shoreline and watching the waves detects motion based on the retinal image of the waves moving. For example, look at the picture below; even though it is a 2D picture, we can perceive the movement of the girl's hair.

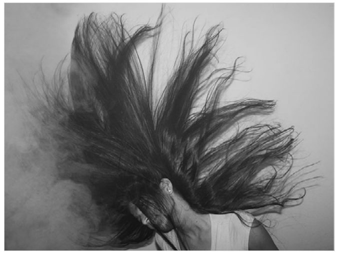

Figure 6.2.a
Source: Shraddha Prabhu

Similarly, we can recognize the kids laughing.

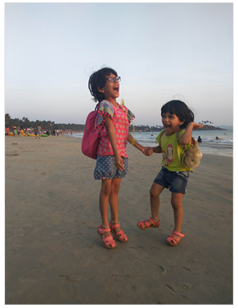

Figure 6.2.b
Source: Shraddha Prabhu

One can tell if something is stationary or moving when looking at a picture of a person, an animal, or a car. A moving item in a photo is a vastly different stimulus than those often used to study the brain underpinnings and mechanics of motion perception. Therefore, extracting motion information from a static image requires deductions based on prior experiences and uses cues embedded in the picture. Motion cues are extracted from scenes and used by the brain to make sense of motion instead of non-motion. Static motion cues are employed by photographers and communication designers all the time and have important implications for the design of Virtual Reality setups.

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For example, the images below show a variety of entities that depict animate movement and inanimate motion. Examples of animate entities (walking, running, sneezing, drinking water) showing movement in photographs:

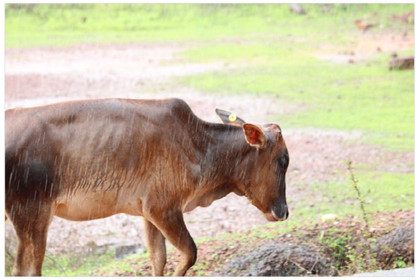

Figure 6.2.c
Source: Shraddha Prabhu

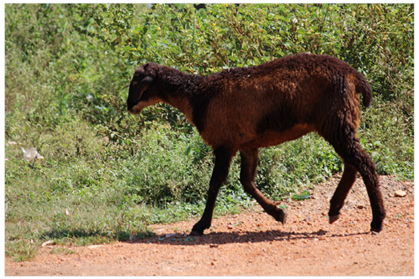

Figure 6.2.d
Source: Shraddha Prabhu

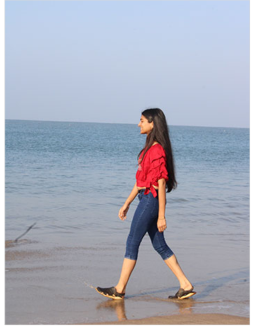

Figure 6.2.e
Source: Shraddha Prabhu

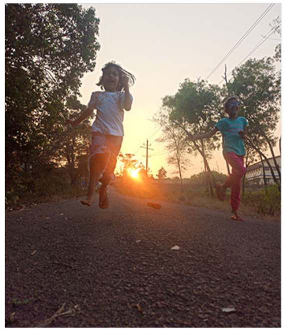

Figure 6.2.f
Source: Shraddha Prabhu

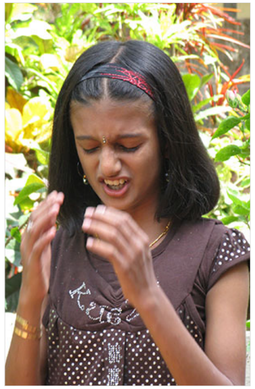

Figure 6.2.g
Source: Shraddha Prabhu

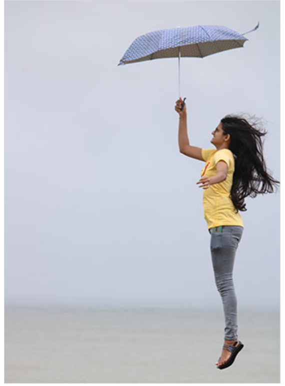

Figure 6.2.h
Source: Shraddha Prabhu

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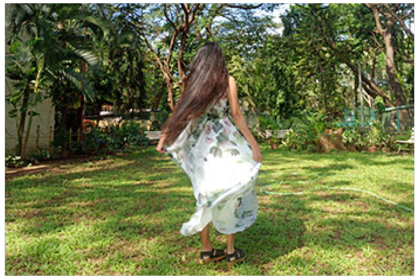

Figure 6.2.i
Source: Shraddha Prabhu

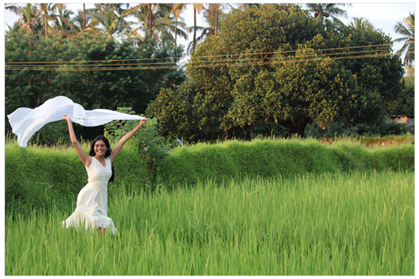

Figure 6.2.j
Source: Shraddha Prabhu

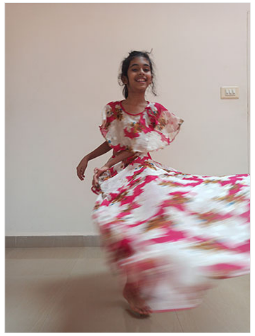

Figure 6.2.k
Source: Shraddha Prabhu

The following images show various motions of inanimate objects. These include waves crashing on the shore, spinning tops, bursting of firecrackers, river, blowing wind, movement of trees, and falling water, among others. All these are easily recognizable by the visual system.

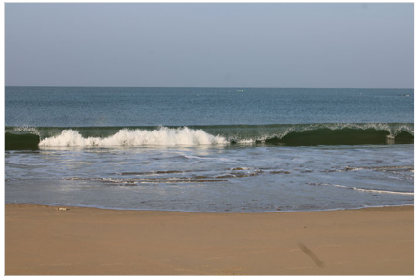

Figure 6.2.l
Source: Shraddha Prabhu

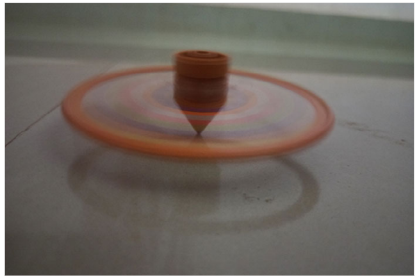

Figure 6.2.m
Source: Shraddha Prabhu

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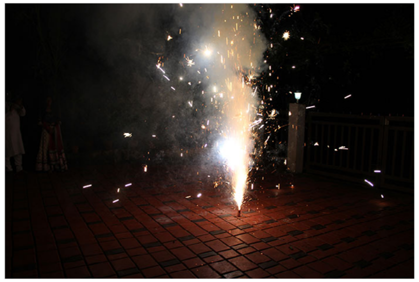

Figure 6.2.n
Source: Shraddha Prabhu

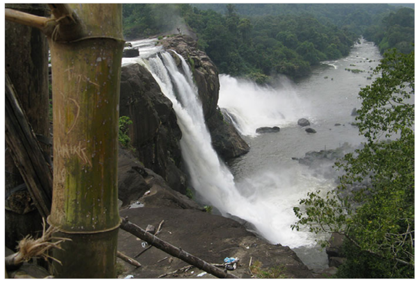

Figure 6.2.o
Source: Shraddha Prabhu

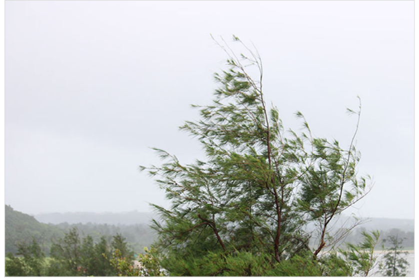

Figure 6.2.p
Source: Shraddha Prabhu

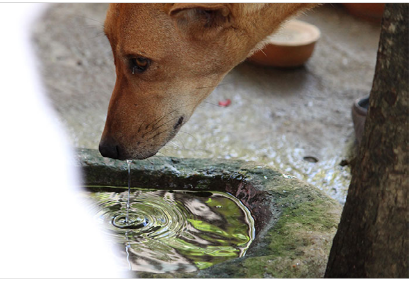

Figure 6.2.q
Source: Shraddha Prabhu

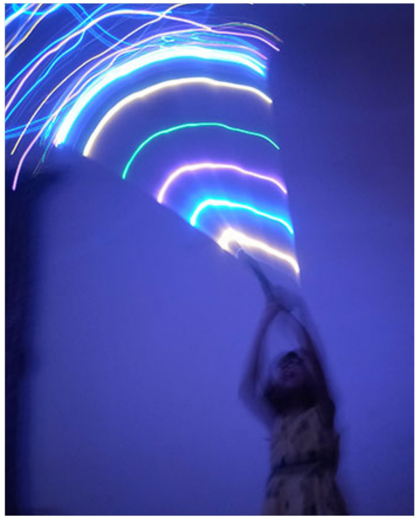

Figure 6.2.r
Source: Shraddha Prabhu

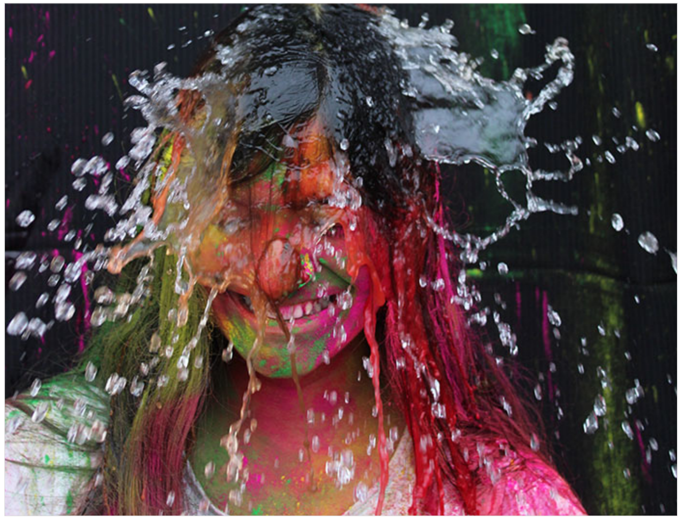

Figure 6.2.s
Source: Shraddha Prabhu

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An important issue is that the brain is able to differentiate between animate movement and non-animate motion. This is done by the brain's multi-sensory integration of sight and sound and various other stimuli. We can hear sea waves differently from falling rain. Similarly, we recognize people walking, jumping, and laughing very easily.

The question of whether suggested motion from visual stimuli activates the same neurons that are engaged in real motion perception has been investigated many times. It has been found that pictures that depict motion could activate the same neurons that one would use if they were watching the action live. Graphic designers and photographers try to develop various pictures that depict motion and change.

Look at the pdf below to know more about the individual elements involved in this type of motion:

- Movement and Motion in Static Images......

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6.3 Primrose Illusion

Is this a wave pool? Can you see the picture move? Or is your mind just playing tricks at you?

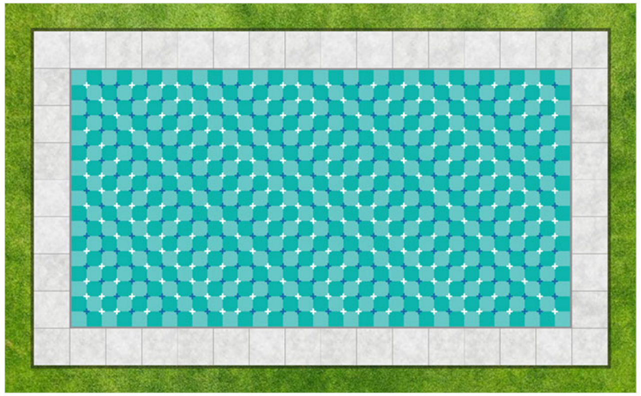

Figure 6.3.a
Source: Shraddha Prabhu

As you can see in the picture above, the optical illusion has a checkered background with alternating teal and light blue squares. Each square has a ‘+’ symbol in white and dark blue in the corners. Only perpendicular straight lines have been used to create the entire image. This is called the Primrose Field illusion by Akiyoshi Kitaoka, inspired by the peripheral drift illusion.

How does this illusion work? What makes it look ‘wavey’?

According to Akiyoshi Kitaoka, two aspects influence the strength of this illusory motion. Firstly, stepwise brightness profiles and contrast levels in colours enhance the peripheral drift illusion.
The ‘+’ symbols are arranged in a diagonal pattern with some variations. There are two rows of ‘+’ symbols on some occasions and one row on others. Kitaoka believed that this variation helped create the wave effect.

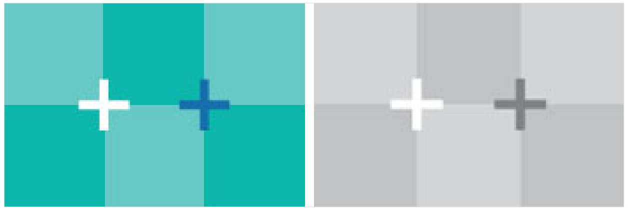

Figure 6.3.b
Source: Shraddha Prabhu

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The sequence of white, dark blue, dark blue, white, dark blue, white, dark blue, white, dark blue, white, dark blue, white, white, dark blue'+' symbols is repeated. White and dark blue '+' characters contrast more than teal and light blue squares. Kitoka believed that the effect becomes prominent because the brain took longer to process lower contrast at the junctions when compared to processing higher contrast.

Movement detectors in peripheral vision detect the time and direction discrepancies, and because they are synchronized for elements of relative orientation, the elements appear to move as coherent blocks. As can be seen, diagonal columns of white primroses alternate with squares of dark pink primroses in the ocean wave illustration below. This was the original illustration provided by Kitoka. As a result, the columns appear to be moving against one another. The specific receptor cells in the retina that are implicated are now being investigated.

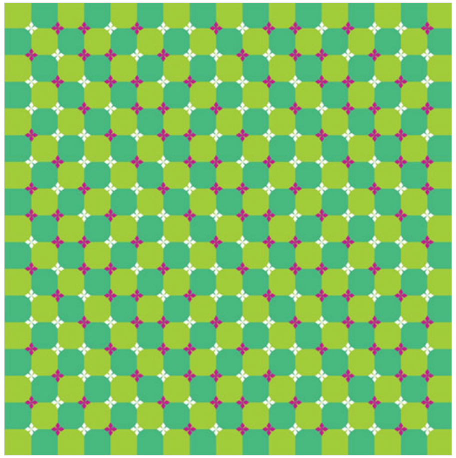

Figure 6.3.c
Source: Shraddha Prabhu

Scientists believe that the optical illusion's waves are caused by 'fixation jitter,' or involuntary eye movements that give the impression that items near what you're fixated on are moving. Another explanation is that dynamic changes in your neuron confuse the motion detectors in your visual cortex, leading you to believe the image is moving.

In this case, it is possible that vision neurons may be responding faster to the higher-contrast elements than the lower-contrast elements. As a result, the higher-contrast elements' motion signals are faster, which makes sense because such contrast-dependent timing disparities would imitate the stimulus sequence moving from the higher-contrast element's position to the lower.
The second aspect that influences the strength of the illusion is fragmented or curved edges. The '+' marks at the corners of each square give them a rounded appearance, which adds to the sense of peripheral drift.

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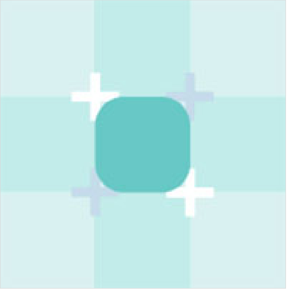

Figure 6.3.d
Source: Shraddha Prabhu

Does changing the ‘+’ symbol to another shape enhance or diminish the illusion?

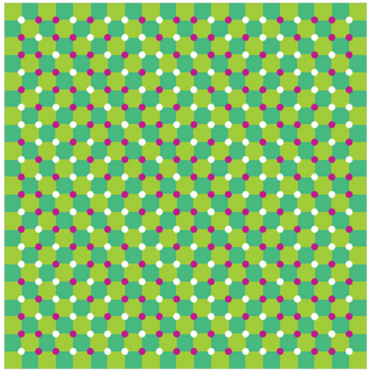

Figure 6.3.e
Source: Shraddha Prabhu

As seen in the picture above, changing the primroses to circles reduced the wave effect. This could be because the primroses and ‘+’ symbols at each square’s corners give it a rounded appearance, which aids in forming waves.

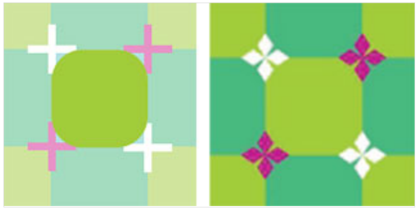

Figure 6.3.f
Source: Shraddha Prabhu

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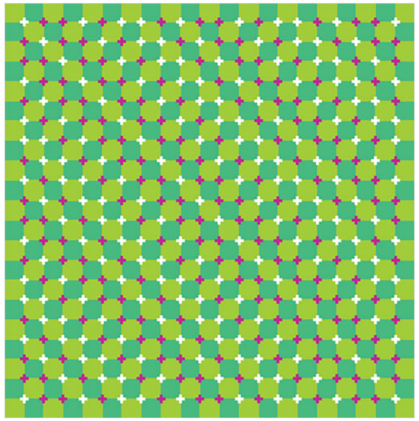

Figure 6.3.g
Source: Shraddha Prabhu

How about when you change the sequence of the '+' symbol?

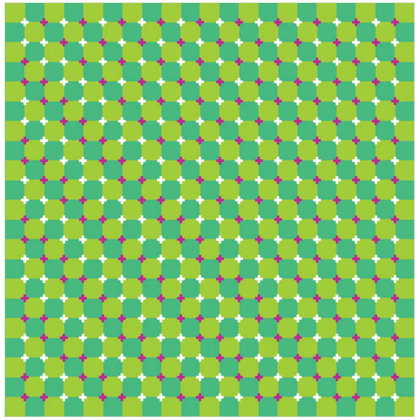

Figure 6.3.h
Source: Shraddha Prabhu

The primroses are arranged in a diagonal sequence with variations in them. Sometimes there are two rows of '+' symbols, and sometimes there is one in the row. The uneven repetitive sequence leads to the 'wave' effect.

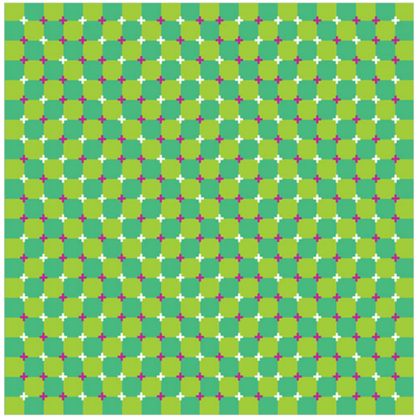

Figure 6.3.i
Source: Shraddha Prabhu

How does changing the background colour affect the illusion?

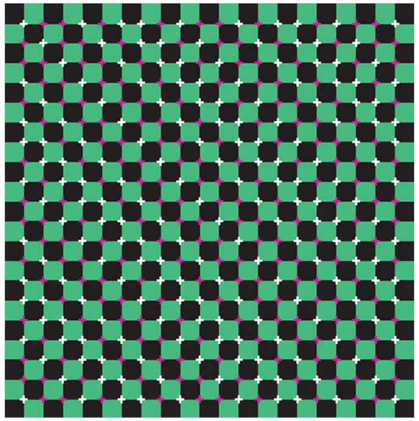

Figure 6.3.ja
Source: Shraddha Prabhu

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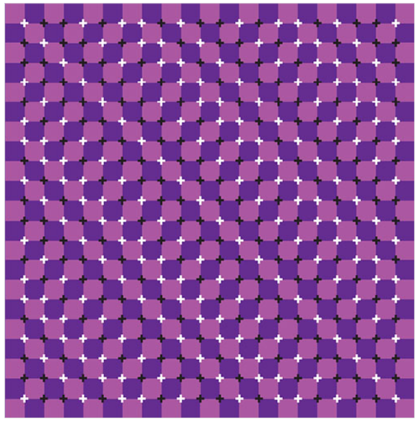

Figure 6.3.jb
Source: Shraddha Prabhu

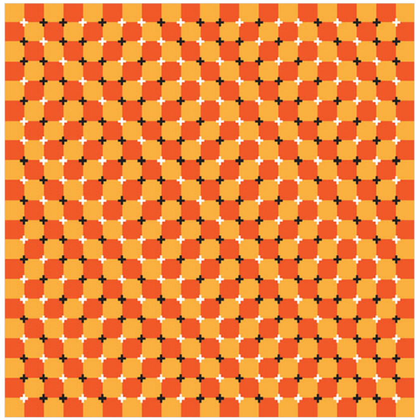

Figure 6.3.jc
Source: Shraddha Prabhu

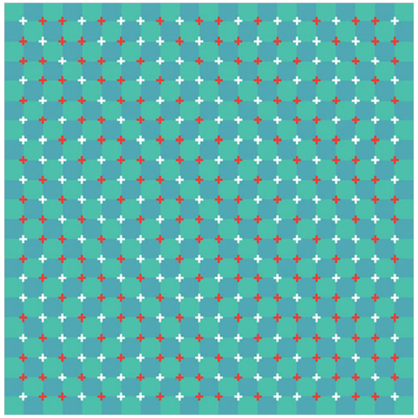

Figure 6.3.jd
Source: Shraddha Prabhu

The wave effect is enhanced when the contrast between '+' symbols is higher than the contrast between the squares.

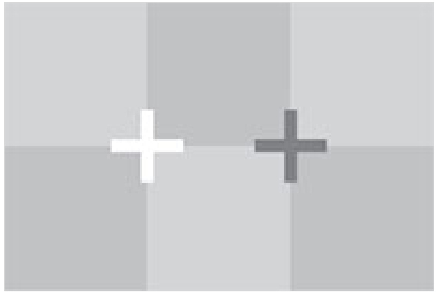

Figure 6.3.k
Source: Shraddha Prabhu

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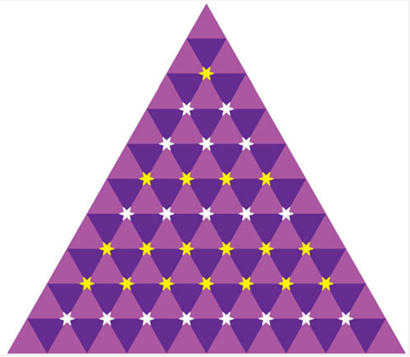

Figure 6.3.l
Source: Shraddha Prabhu

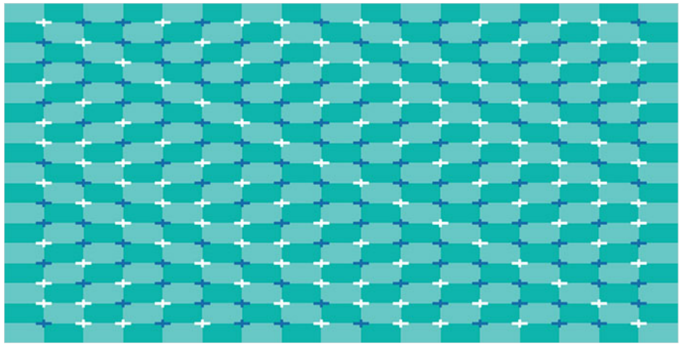

Figure 6.3.m
Source: Shraddha Prabhu

The above explorations (Figure 6.3.l and 6.3.m) show that the illusion can only be observed in rectilinear shapes. The results of this exploration will be helpful for graphic designers working in the textile industry who are involved in creating shapes and patterns.

- Primrose Illusion......

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6.4 Ouchi Illusion

The research community was first made aware of this eye-catching illusion by Spillmann, Heitger, and Schuller in 1986. Graphic artist H. Ouchi designed the illusion consisting of two orthogonally oriented black-and-white rectangular checkerboard patterns that form a backdrop orientation around an inner ring.

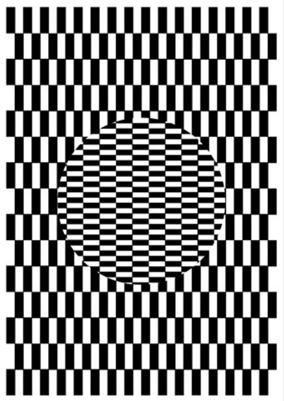

Figure 6.4.a
Source: Reshma Issac

According to Kitaoka and Ashida (2003), two factors affect the strength of the illusion. The first is the stepwise luminance, where the smoother the luminance profile, the weaker the illusion. The Ouchi illusion mainly works due to the stark contrast between the white and the black tiles. Second, the researchers suggest that curved or fragmented edges enhance the illusion, where they say the more extended the edge is, the weaker an illusion would be. As we can see in the Ouchi illusion, there are hardly any long edges; it consists of small, disjointed rectangles.

The rectangles inside the circular region are oriented at a right angle to those in the rest of the figure. This creates an impression of relative motion when the whole pattern is moved.

At the level of phenomenal everyday experience, two simultaneous events appear when we look at the Ouchi Illusion. First, there is a 'decoupling' effect of the circular checkered region in the centre from the checkered background. Further, the circular disk appears to float atop the background.

Second, the rectangles in the circle become jittery when the whole image is moved.

These phenomena can be comprehended separately and used together to explore the Ouchi illusion in greater detail visually.

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Visual Perception for Communication Designers

Human Factors and Sociotechnical Systems Studios
by
Vivek Kant and Sruthi Sridhar
IDC, IIT Bombay

Source:
https://www.dsource.in/course/visual-perception-communication-designers/6-illusory-motion/64-ouchi-illusion

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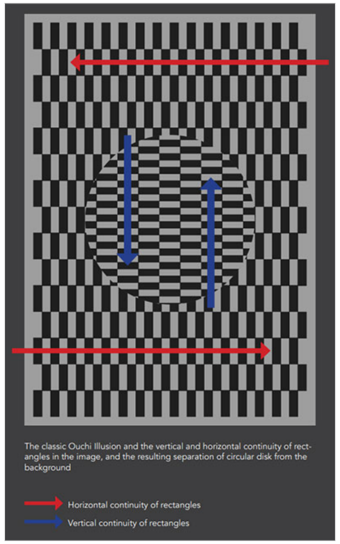

The classic Ouchi Illusion and the vertical and horizontal continuity of rectangles in the image, and the resulting separation of circular disk from the background

Horizontal continuity of rectangles
Vertical continuity of rectangles

Figure 6.4.b
Source: Reshma Issac

Further, the relative motion of the rectangles at the centre circle may also be caused by the excitation of spatially overlapping ON and OFF regions of the centre-surround receptive fields. Small retinal movements show the segmentation of the embedded pattern and motion of the inset in relation to the surrounding. A multitude of perspective distances and angles result in the illusion (Shapiro & Todorović, 2017).

Here are some of the explorations when the relative motion and the sense of decoupling are manipulated.

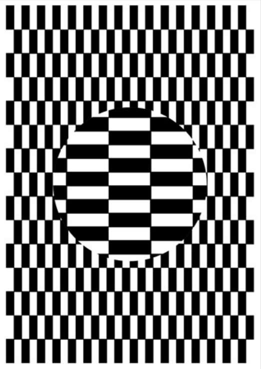

Figure 6.4.c
Source: Reshma Issac

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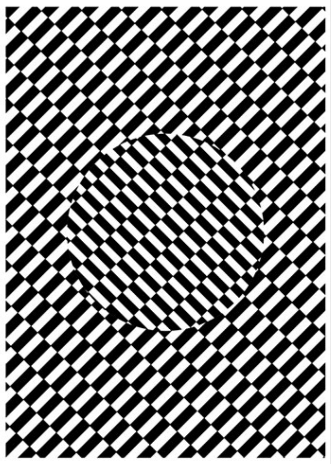

Figure 6.4.d
Source: Reshma Issac

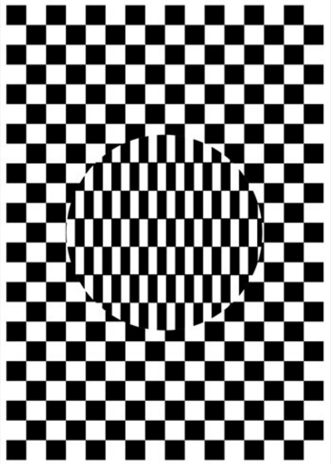

Figure 6.4.e
Source: Reshma Issac

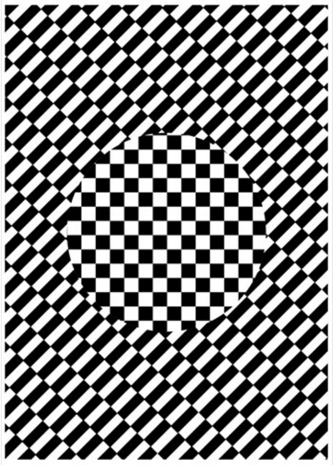

Figure 6.4.f
Source: Reshma Issac

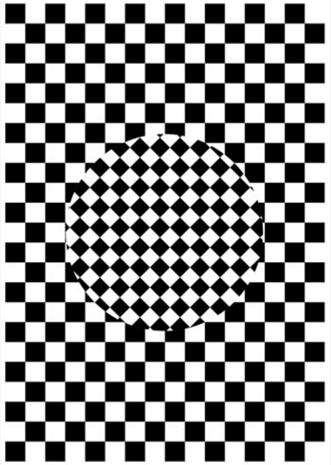

Figure 6.4.g
Source: Reshma Issac

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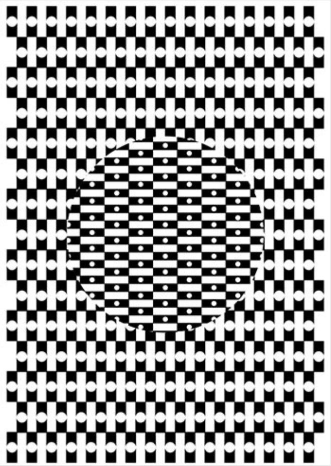

Figure 6.4.h
Source: Reshma Issac

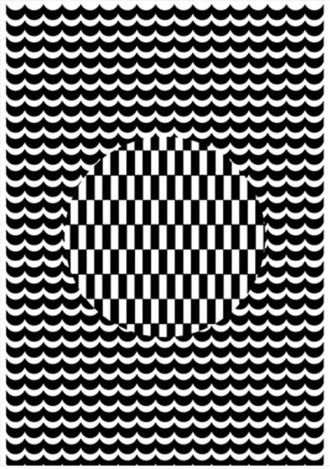

Figure 6.4.i
Source: Reshma Issac

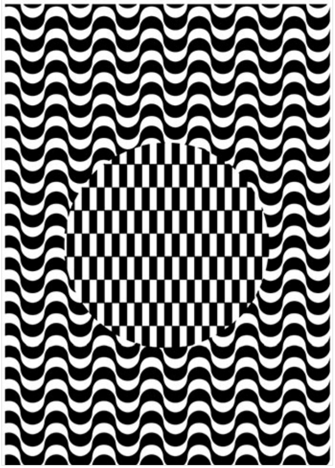

Figure 6.4.j
Source: Reshma Issac

To understand more about how these explorations work and the illusion, please look at the link below:

- Ouchi Illusion......

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Source:
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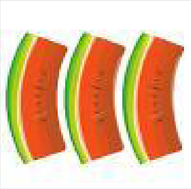
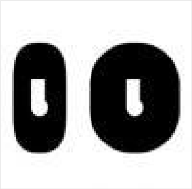
7. Size and Distance

7.1 Size and Distance Perception

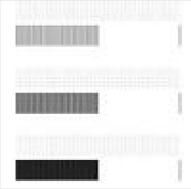
7.2 Occlusion



7.3 Jastrow Illusion



7.4 Delboeuf Illusion



7.5 Oppel Kundt Illusion

7.6 Forced Perspective

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7.1 Size and Distance Perception

Here are two images of a cobra. Can you guess the size of the cobra?

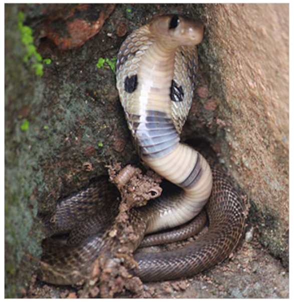

Figure 7.1.a
Source: Shraddha Prabhu

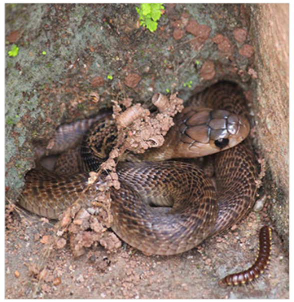

Figure 7.1.b
Source: Shraddha Prabhu

Is it not easier to guess the size of the cobra in the second image compared to the first? Why is it so? Even though the texture of the background in the first image may lead us to believe that the cobra is small, there are no distinct distance or depth cues to suggest its actual size. However, in the second picture, we have a yardstick; we have a millipede which we can use as a reference. The millipede present nearby is a clue that gives us an estimate of the cobra's approximate size. Therefore, the cobra seems much bigger in the second picture. What are the factors that affect our size perception?

Visual angle is one factor that affects our size perception, and it is the angle of an object relative to the observer's eye. The visual angle depends on the size of the stimulus and its distance from the observer. The closer the stimulus is to the observer, the greater the visual angle. For example, you will be able to see the entirety of a monument from afar, but as you go near the monument, you will only be able to see parts of it. The below are from the Sun Temple in Konark, Odisha.

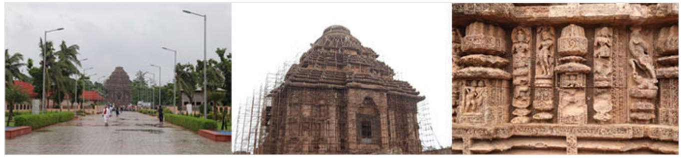

Figure 7.1.c, d, e
Source: Sravan Sridhar

However, at certain times a small object that is near can have the same visual angle as a large object that is further away. For example, the picture of what looks like a boy being picked up by a fork. To take this picture, the photographer adjusted the distance between the fork and the boy such that the fork which is closer to the camera looks like it is picking up the boy. The fork had the same visual angle as the boy in this photograph.

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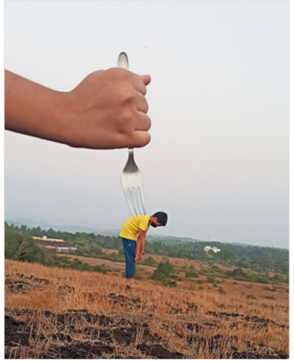

Figure 7.1.f
Source: Shraddha Prabhu

The examples above also demonstrate the relationship between size and depth perception, and particularly it asserts that accurate size perception fosters good depth perception (also related to the previous section). And while our impression of size is not always accurate, it was good enough for psychologists to suggest the size constancy principle. This principle asserts when we observe an item from different distances, the size of the object's picture on the retina varies; however, our impression of its size remains relatively constant.

For example, when walking toward your friend in a mall, the size of your friend will constantly change on your retina as you move towards them (see Appendix A); however, your perception of their height will not change. When you are nine feet away, they don't seem to be 3 feet tall as opposed to appearing 6 feet tall when they are 3 feet away.

Another source of size constancy is relative size. We frequently use known object sizes as a yardstick for judging the size of other objects. This can be seen in the case of the cobra; even though we did not know the actual size of the cobra, we perceived it to be large once there was a millipede for comparison. We can guess the size of the millipede from our experience and use it as a yardstick to measure the size of the cobra.

This concept that nearby things influence our perceptions of object sizes can be used in various ways while designing a poster. As a designer, for creating effective communication, size and relative scaling play an essential part in structuring the objects in a poster.

Another great example of relative size is displayed in the picture below. The object closer to us will occupy more field of view than an object farther away. From previous experience, we can judge the size of a human being. Therefore, instead of perceiving the boy to be standing on the girl's palm, we perceive the boy to be standing much farther away than the girl.

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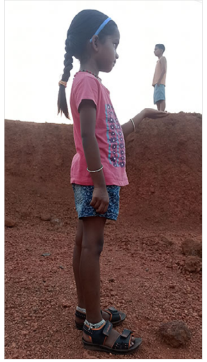

Figure 7.1.g
Source: Shraddha Prabhu

The picture below looks like the girl exhaling smoke out of her mouth. The picture is taken at such an angle that the cloud in the sky seems like smoke coming out of her mouth. This illusion largely works because of the absence of depth cues in the picture. Familiar objects like the sun, moon, and clouds give away the illusion as we have information about their size from past experiences. Using this information, we tend to evaluate the distance between surrounding objects. There are no such cues in the picture below; therefore, we perceive it as the girl exhaling smoke through her mouth.

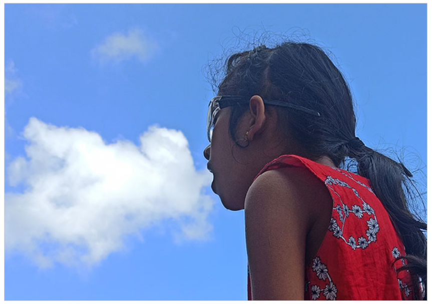

Figure 7.1.h
Source: Shraddha Prabhu

It is also important to ensure that the background is not cluttered due to the abovementioned points. A cluttered background can diminish the illusion as it may contain a lot of depth cues. In the example below, the image on the left has a lot of depth cues, like the tiles on the floor, the railings, and their reflection on the floor. Moreover, the door in the picture acts as a familiar object, which allows us to perceive the little girl's height in the background. When the photo is cropped (the image on the right), these cues are eliminated, making the illusion more plausible.

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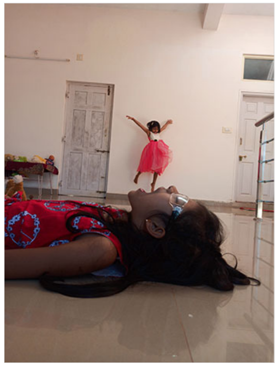

Figure 7.1.i
Source: Shraddha Prabhu

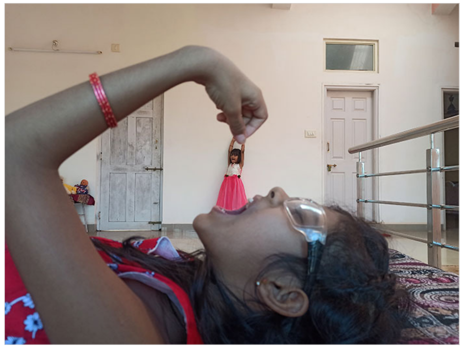

Figure 7.1.j1
Source: Shraddha Prabhu

Relative height is another source that helps us maintain size constancy. Even though the image is meant to look like a girl being crushed by two small vehicles, the relative heights in the image diminish the illusion. We view an object (in this case, the girl) to be closer to us if the point of contact between the object and the ground is lower, and when it rises, we perceive the object (the bus) to be farther away.

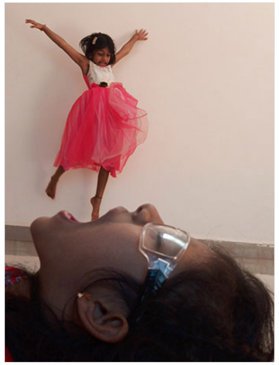

Figure 7.1.j
Source: Shraddha Prabhu

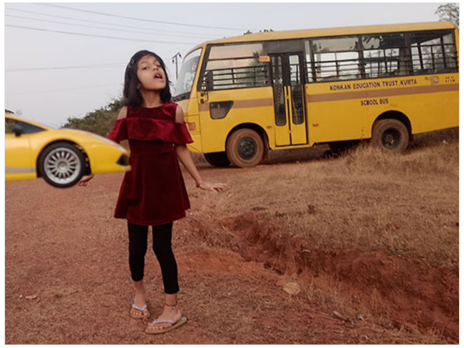

Figure 7.1.k
Source: Shraddha Prabhu

Similarly, the point of contact between the boy and the ground is lower than the point of contact between the bus and the ground, giving the impression that the bus is further away.

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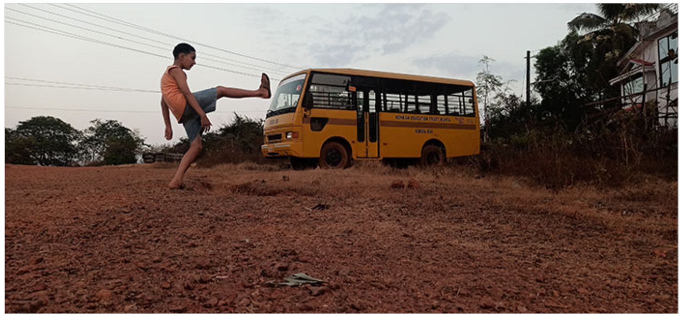

Figure 7.1.l
Source: Shraddha Prabhu

Changing camera angles can also help enhance the size distance illusion by correcting the relative height. For example, when the camera angle is lowered, it helps shorten the distance between the point of contact between the girl and the ground. It also helps shorten the distance between the people at the back and the ground, intensifying the illusion.

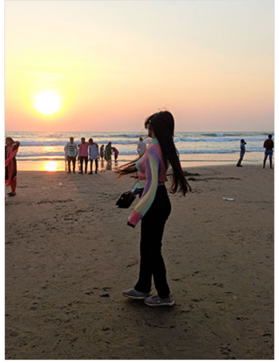

Figure 7.1.m
Source: Shraddha Prabhu

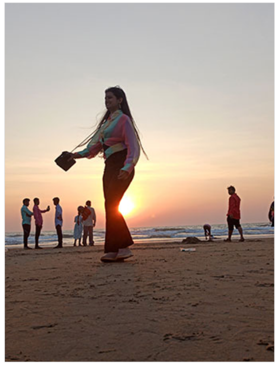

Figure 7.1.n
Source: Shraddha Prabhu

Another source of size perception is the relationship between the texture on the ground and the object. For example, there was an attempt to create an illusion where the boy looks like he is hanging onto the umbrella's edge in this picture. However, this illusion does not work because of the textural cues on the ground (grass). The grass on the ground is a significant indicator of depth in this situation. The grass is tall and sparse around the girl's feet. It eventually becomes shorter and denser around the boy, causing us to perceive their distance. Moreover, we can tell they are the same size because their bases (legs) cover the same grassland area.

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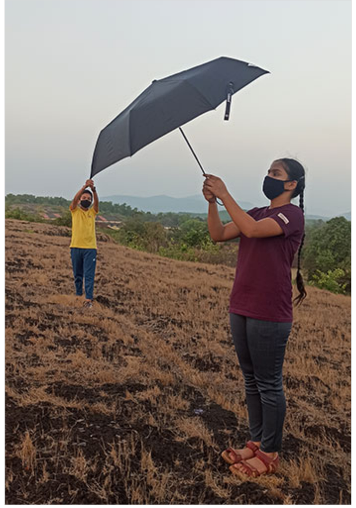

Figure 7.1.o
Source: Shraddha Prabhu

Another example is when the camera angle is changed to reduce the texture gradient, and the illusion works better. There is an illusion of the boy being picked up on a fork in the picture below. The illusion does not work well in the first picture, but the effect is aided by shifting the camera angle to decrease the noisy background. The gradient on the ground is reduced in the bottom image due to the shift in camera angle. The size-distance illusion gets stronger as the depth cues are removed.

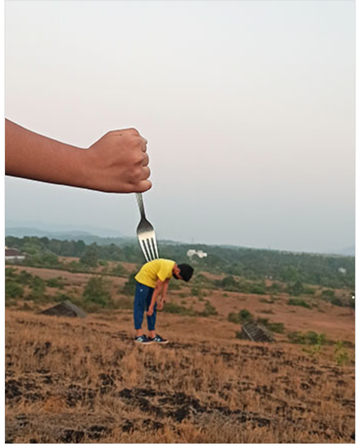

Figure 7.1.p
Source: Shraddha Prabhu

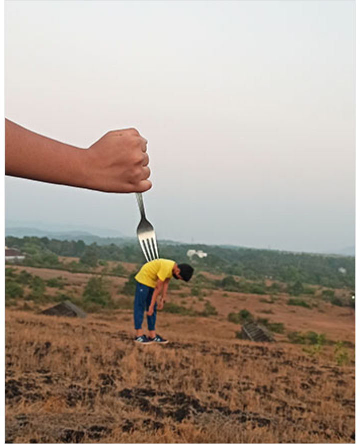

Figure 7.1.q
Source: Shraddha Prabhu

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Texture gradient occurs when elements in a picture that are evenly spaced appear to be more closely packed as the distance between them increases. For example, here is an instance when this is not the case. Although the intention was to create an illusion where the flower is as big as the person standing next to it, it fails because of the flowers in the background. The repetition of similar objects across the image functions as a gradient, allowing us to feel the depth in this image. Closer to the camera, the marigold flowers are larger. And even though farther away, the flowers continue to get smaller and closer, the illusion does not work because they are not evenly spaced. Therefore, texture is an essential cue in perceiving size and distance.

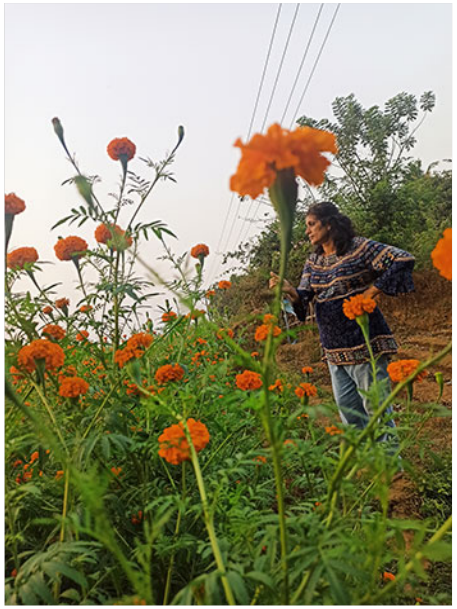

Figure 7.1.r
Source: Shraddha Prabhu

Due to the lack of cues like depth, surrounding objects gradients, etc., we may fail to perceive the actual distance of an object. This false perception of an object's distance from the observer might make the item appear larger or smaller than its actuality. This is referred to as the size-distance illusion. What are the various cues that give away size distance illusion?
The difference in clarity or focus of the picture is essential for this illusion to work. The girl is "in focus" in the image on the left, while the Rubik's cube is out of focus. The Rubik's cube is "in focus" in the image on the right, while everything else is blurred. These images are meant to give the impression that the girl is placing her index finger on an unusually large Rubik's cube. But why doesn't it appear so? We perceive a substantial distance between the Rubik's cube and the girl because of the change in focus, which works as an obvious depth cue in an image.

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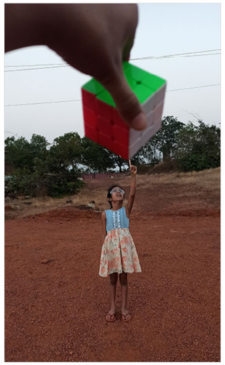

Figure 7.1.s
Source: Shraddha Prabhu

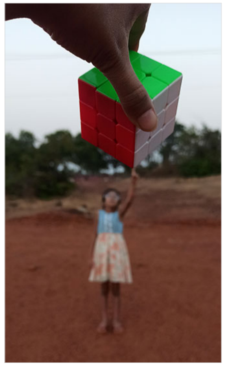

Figure 7.1.t
Source: Shraddha Prabhu

Reflection while taking the picture is also an important clue. The attempt was to create an illusion that looks like an infant standing on a lady's palm. However, two distinct reflections can be seen in the photograph. The two reflections are also of different sizes, where the lady's reflection is substantially bigger than the toddler's reflection. Therefore, the illusion is quickly dispelled since the reflection in the water does not match what we perceive.

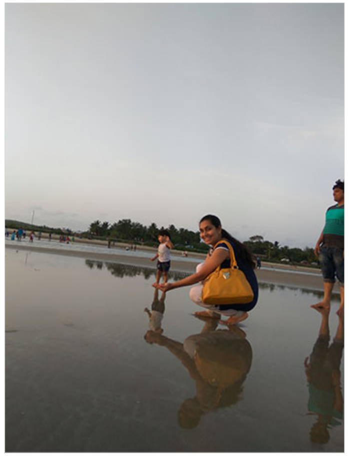

Figure 7.1.u
Source: Shraddha Prabhu

Similarly, shadows play a role in the perception of these illusions. Shadow plays a vital role when we try to create an illusion of two connected entities, like in the example of a woman dangling from the man's hand. In the first picture, it is apparent that they are standing at different distances because of the shadow. But the illusion seems to work once the shadows are removed, and the picture's brightness and contrast are increased.

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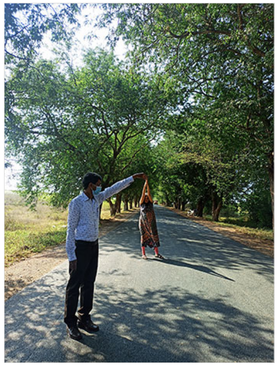

Figure 7.1.v
Source: Shraddha Prabhu

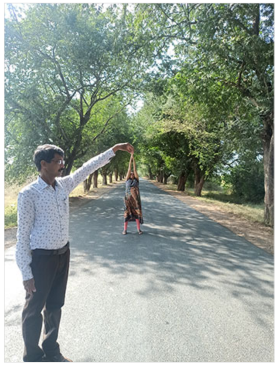

Figure 7.1.w
Source: Shraddha Prabhu

However, shadows do not hinder as much if the entities are separate from one another as opposed to the entities being together, as can be seen in the pictures below. This is because shadows and reflection work as a cue that lets us know the distance between the two entities, where the smaller the shadow/reflection, the farther away the object from the camera. Therefore, it is vital to ensure there are no shadows or reflections when trying to create a size distance illusion.

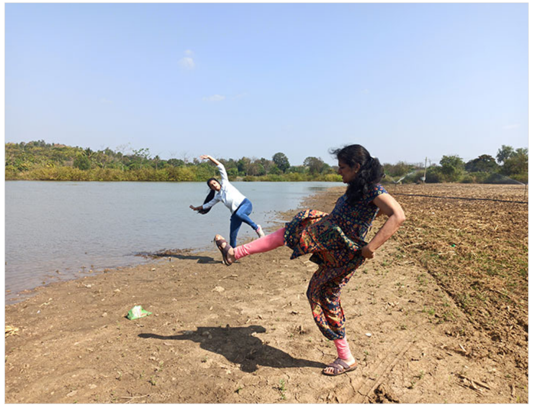

Figure 7.1.x
Source: Shraddha Prabhu

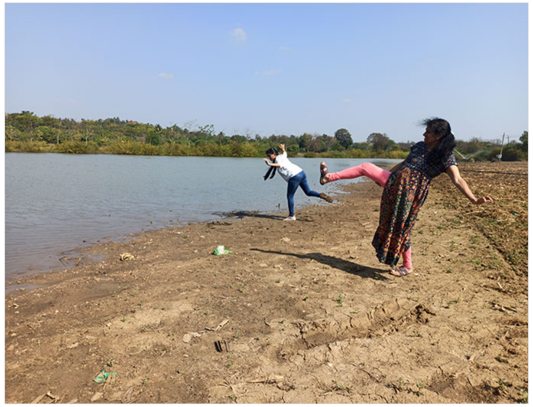

Figure 7.1.y
Source: Shraddha Prabhu

Does having the same colour cues enhance or facilitate the perception of the illusion? In the example below, the toy car and the school bus are of the same yellow shade and are against the same contrasting background. According to the gestalt law of similarity and grouping, we should put these two together and perceive them to be of similar sizes, thereby ignoring other depth cues like texture. However, that is not the case because of the uneven texture of the ground. Moreover, the toy car is slightly out of focus, greatly diminishing the illusion.

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IDC, IIT Bombay

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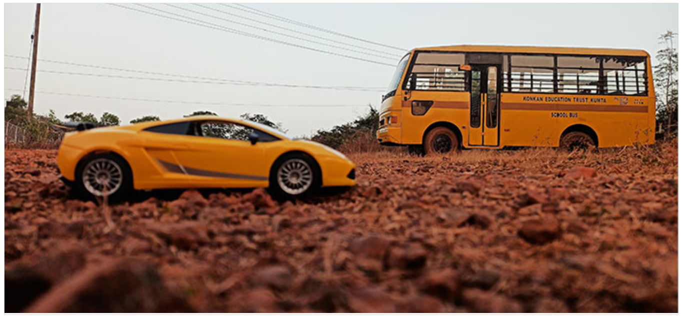

Figure 7.1.z
Source: Shraddha Prabhu

However, the example below works even when some parts of the picture are occluded. The lady in the picture is wearing an outfit that is the same colour as the brinjal, which helps us group them. The occlusion in the picture facilitates the illusion because we cannot see the texture of the ground where the lady is standing, which makes the grouping in the images easier and the illusion more plausible.

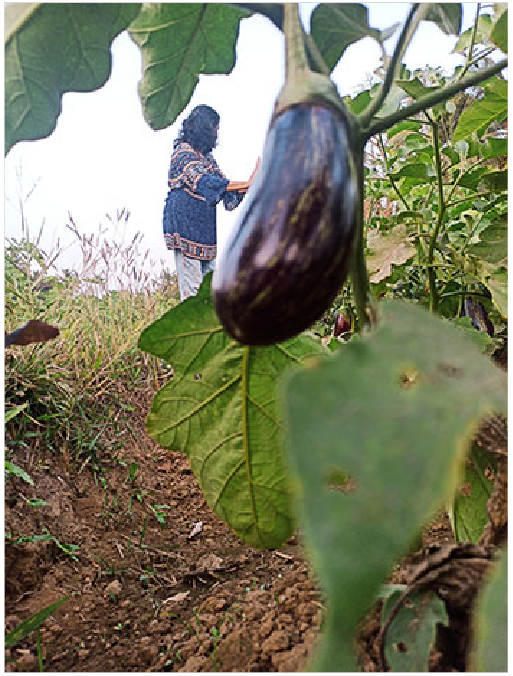

Figure 7.1.aa
Source: Shraddha Prabhu

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Depth cues play a vital role in our perception of these illusions. Is it the same case when we remove the colour? Would it make a difference if the photographs were in black and white? Here are examples of two explorations.

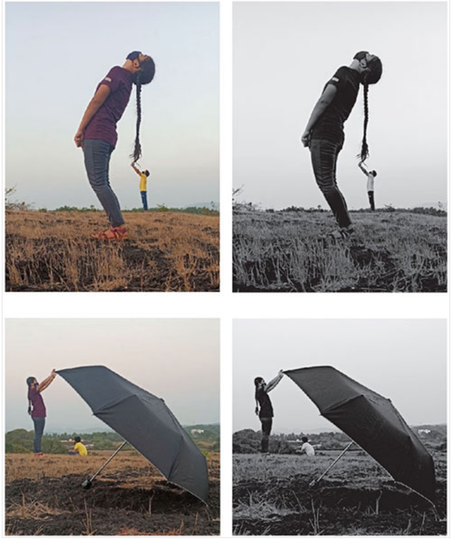

Figure 7.1.ab
Source: Shraddha Prabhu

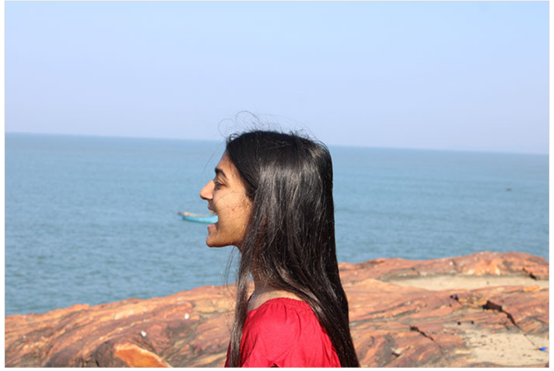

Figure 7.1.ac
Source: Shraddha Prabhu

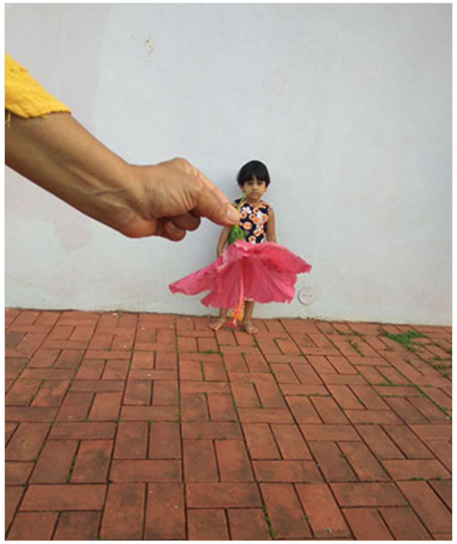

Figure 7.1.ad
Source: Shraddha Prabhu

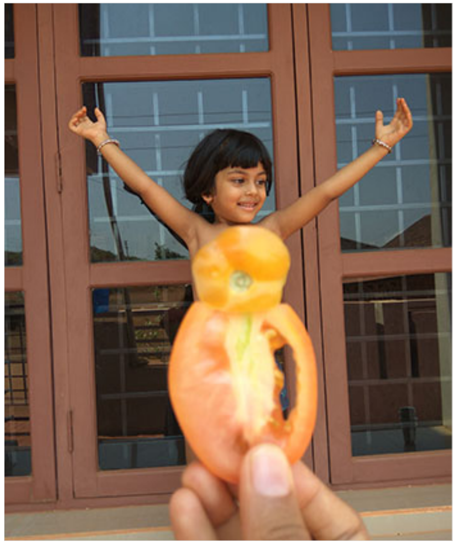

Figure 7.1.ae
Source: Shraddha Prabhu

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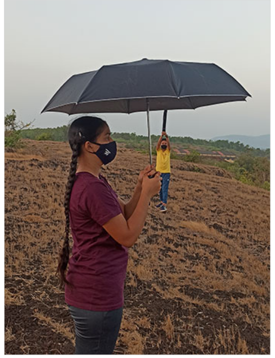

Figure 7.1.af
Source: Shraddha Prabhu

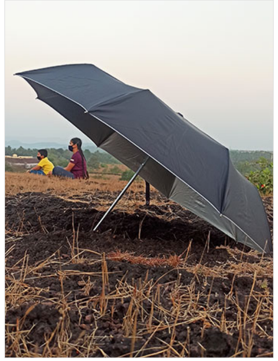

Figure 7.1.ag
Source: Shraddha Prabhu

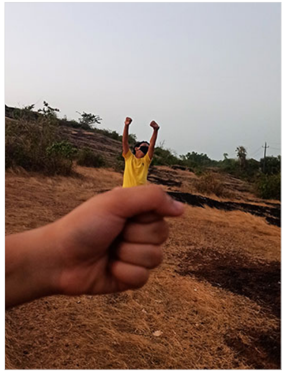

Figure 7.1.ah
Source: Shraddha Prabhu

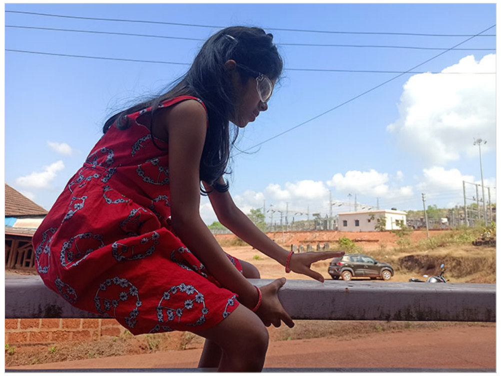

Figure 7.1.ai
Source: Shraddha Prabhu

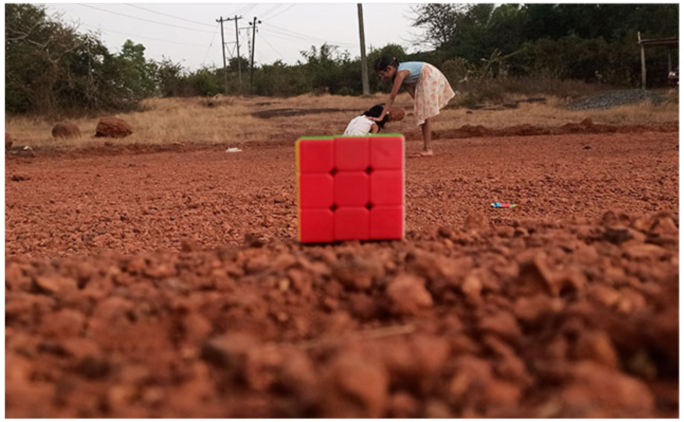

Figure 7.1.aj
Source: Shraddha Prabhu

The depth cues are much more prominent in color images when compared to black and white pictures. Therefore, the illusions work better in black and white as depth cues are not as noticeable.

Here is the pdf exploring this phenomenon:

- Size and Distance Perception......

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7.2 Occlusion

Occlusion occurs when one object completely or partially obscures another from the view. The river in the photograph is considered farther distant than the trees because the partially hidden object is seen as further away.

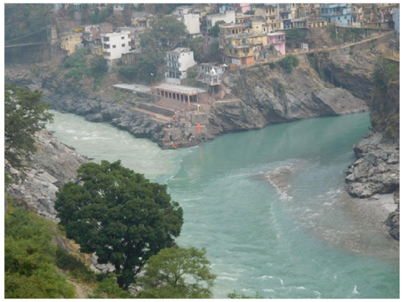

Figure 7.2.a
Source: Sravan Sridhar

Occlusion only conveys a relative distance; it does not provide information about an object's absolute distance. Although we can infer from occlusion alone that the partially covered object is farther away than the other object, we will not be able to determine the exact distance.

Which circle would you say is bigger than the other? Doesn't the circle on the right seem bigger than the circle on the left?

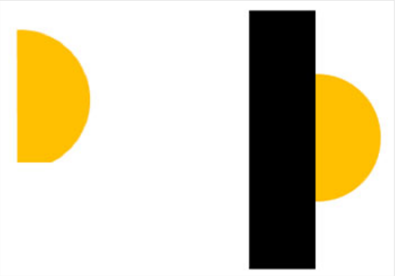

Figure 7.2.b
Source: Sruthi Sridhar

A figure bounded by an occluding edge, like the one in the image below, seems larger than a similar figure that is not bounded by one. This could be explained by various means, including the Gestalt principle of Pragnaz, where the occluding bar is perceived as a whole, and the entity which is occluded is perceived as a whole circle.

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As the circle is "occluded," it is perceived to be hidden behind the black bar, and it is perceived to be farther away from the viewer. According to the perspective theory, when the object's size on the retina is the same, an object farther away appears larger than an object closer. Therefore, as we perceive the occluded circle to be behind the black bar, it appears bigger in the example above. In contrast, the semicircle, which is not obstructed by anything and occupies the same retinal space, looks closer to the viewer and is perceived as smaller than the "obstructed circle."

Here are a few more explorations of the different types of occlusion

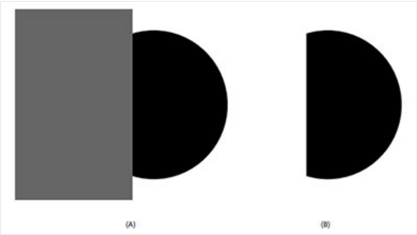

Figure 7.2.c
Source: Swati Yadav

When less than half of a circle is occluded, A still looks bigger than B.

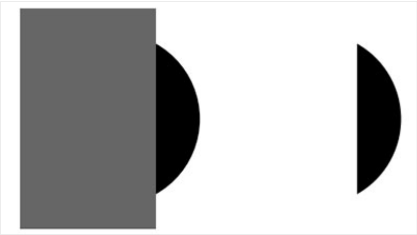

Figure 7.2.d
Source: Swati Yadav

Similarly, when more than half of the circle is occluded, A still looks bigger than B.

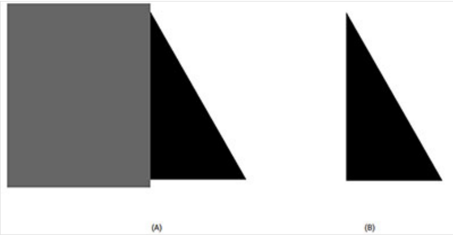

Figure 7.2.e
Source: Swati Yadav

When we change shapes and swap the circle for a triangle, the occluded triangle in A is still perceived as longer and larger than B.

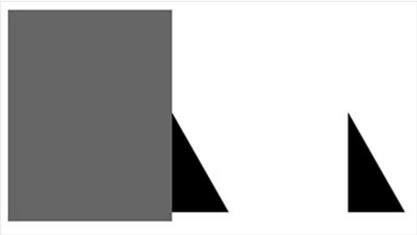

Figure 7.2.f
Source: Swati Yadav

Even if the shape of the rectangle (occluding shape) changes, the occluded triangle still looks larger than B; however, the illusion is not as strong as in previous cases.

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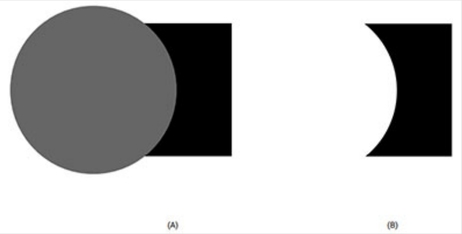

Figure 7.2.g
Source: Swati Yadav

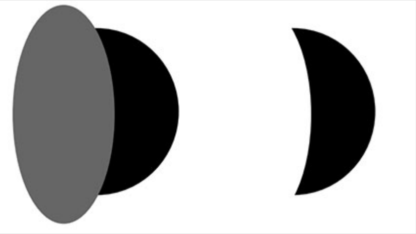

Figure 7.2.h
Source: Swati Yadav

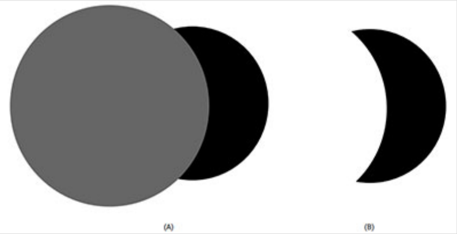

Figure 7.2.i
Source: Swati Yadav

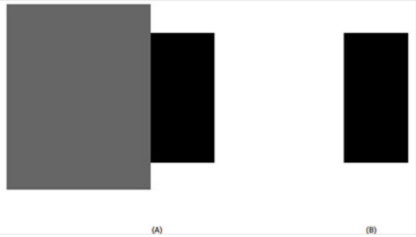

Figure 7.2.j
Source: Swati Yadav

The effect might not be as robust in these examples above. Because in Figure 7.2.g, we would perceive the circle to be occluding an entire square. Therefore, comparing it with B is like comparing two different shapes, which diminishes the illusion. The same applies to the rest of the explorations.

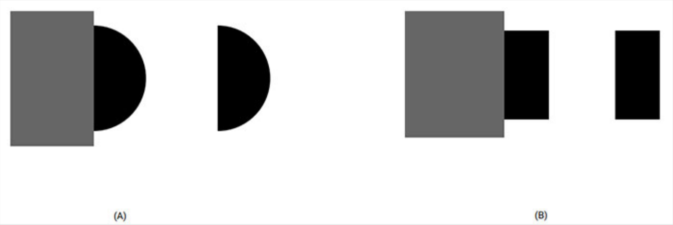

Figure 7.2.k
Source: Swati Yadav

If we compare the two phenomena, it is more pronounced in A than in B. This could be because we do not immediately perceive B as a rectangle occluding a square. Instead, because we are familiar with different shapes of rectangles, we perceive the black box to be another rectangle.

In the picture below, which among the three, A, B or C, looks the longest?

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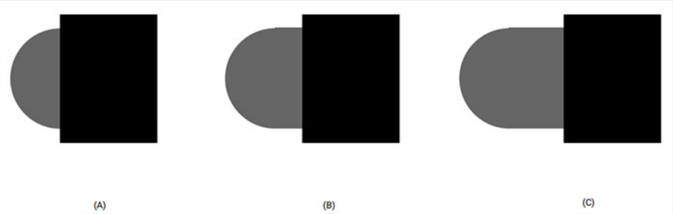

Figure 7.2.l
Source: Swati Yadav

One would most probably say C. When one manipulates and reduces the occluded area by keeping the size of the occluding region the same, the part with the least occluded area seems the largest. In this case, C.

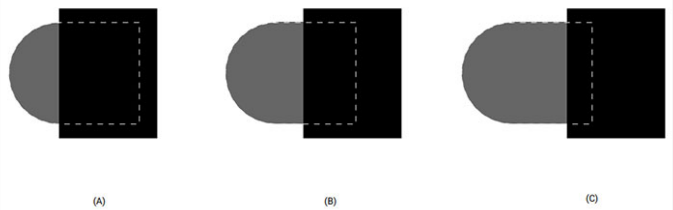

Figure 7.2.m
Source: Swati Yadav

Here are a few more explorations using different shapes.

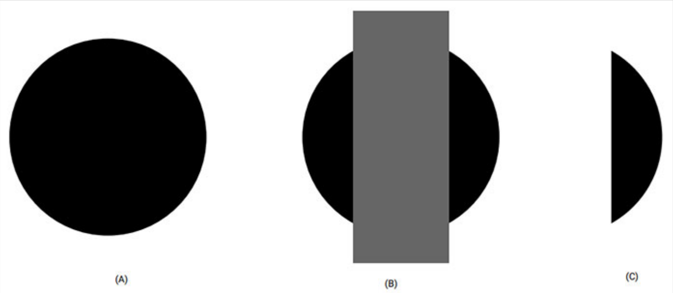

Figure 7.2.n
Source: Swati Yadav

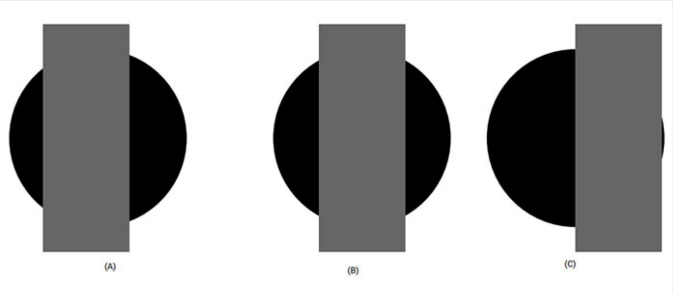

Figure 7.2.o
Source: Swati Yadav

Occlusion is a phenomenon used by designers quite extensively in displaying information or purposefully hiding information. More broadly, the viewer is "involved" in "filling up" the parts hidden by occlusion. Here are some real-life explorations of occlusion. Notice how the mind perceives this information?

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In the picture below, we see a cow that looks like it has an unnaturally long body. We see a pillar occluding the cow.

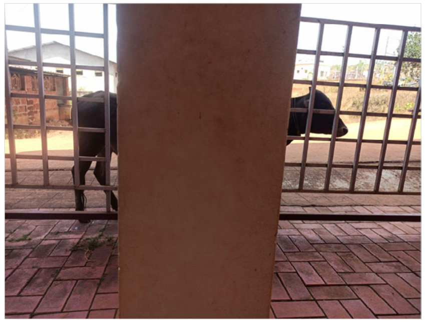

Figure 7.2.p
Source: Shraddha Prabhu

The pillar makes us perceive the body to be of one cow when two cows (see below) are standing there. The occlusion of the pillar makes us perceive the cow to have a bigger body than it does.

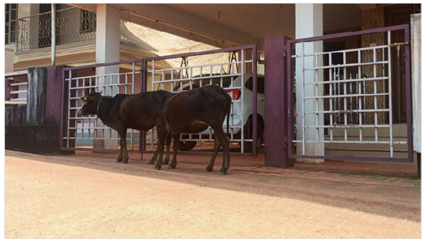

Figure 7.2.q
Source: Shraddha Prabhu

Similarly, in the picture below, we see a girl with crazy hair. When in fact, it is a picture of the girl standing in front of a tree. The branches of the trees look like extensions of the girl's hair.

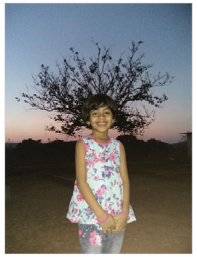

Figure 7.2.r
Source: Shraddha Prabhu

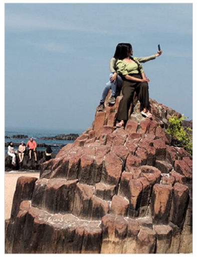

Figure 7.2.s
Source: Shraddha Prabhu

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7.3 Jastrow Illusion

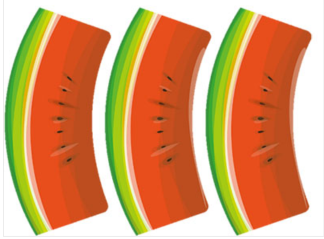

Figure 7.3.a
Source: Harmeet Kaur

There are three slices of watermelon in the picture above. Which piece looks the biggest? If you are like most people, the slice on the far left will look the smallest, and the middle portion will look smaller than the slice on the far right. This is the Jastrow illusion. When two similar figures are positioned next to each other, the Jastrow illusion is created. Even though they are both the same size, one appears to be larger.

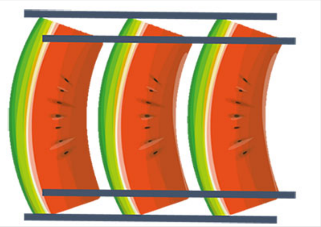

Figure 7.3.b
Source: Harmeet Kaur

The Jastrow illusion was named after Joseph Jastrow, an American psychologist who first identified it in 1889. Jastrow illusion is also known as Wundt area illusion, Wundt – Jastrow illusion or Ring – segment illusion. When two curved forms with identical measurements are put next to each other, the Jastrow illusion occurs. When looking at the two shapes side by side, one appears to be substantially larger than the other. The Jastrow illusion still occurs when the two shapes' positions are reversed or changed in orientation.

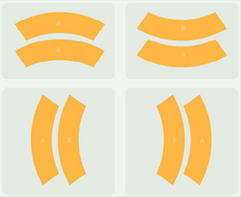

Figure 7.3.c
Source: Amit Patjoshi

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Two identical figures, “A” and ‘B’ are placed adjacent to each other, and both figures are then rotated in increments of 90 degrees. As it can be observed, the Jastrow illusion still holds in place despite the objects’ orientation.

Scientists are still puzzled as to why one of the figures in the Jastrow illusion appears larger than the other. Researchers have observed similar results using a variety of geometric shapes, such as trapezia, parallelograms, and diamonds. But does it work better in curved shapes or straighter shapes? The figures below show two identical shapes with uneven sides curved from the centre. The illusion still occurs when the shapes are straight but are less prominent. The illusion becomes stronger as the curve increases. The brain is tricked into interpreting one form as long and the other as short since the shorter side of one figure is close to the longer side of the other; however, it is unclear why.

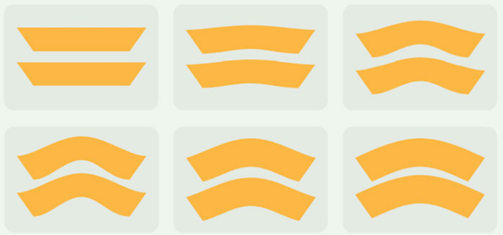

Figure 7.3.d
Source: Amit Patjoshi

How about the thickness of the shape? Does the extent of the illusion change with the thickness? The exploration below changed the thickness of two identical lines from 1 point to 25 points, and they were placed next to each other. The illusion appears to be almost non-existent with thin lines. However, as the thickness increases, the illusion becomes more prominent.

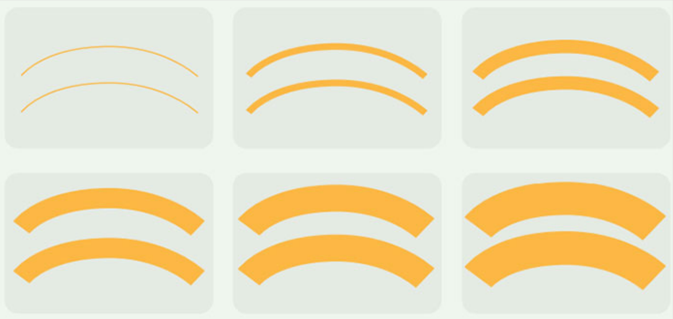

Figure 7.3.e
Source: Amit Patjoshi

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Although there are a couple of explanations for the Jastrow illusion, scientists are still unable to reach a consensus. One theory relates to how the mind perceives the 2D images on the retina in the context of a 3D world. Another idea is that the mind can only focus on a small field of vision, which is then reconstructed by our consciousness. The most prevalent explanation is that the contrast in size between the large and small radius confuses the brain. The long side makes the short side appear even shorter, while the short side makes the long side appear even longer. Another explanation is that the lower figure looks to be longer because the longer side contrasts with the shorter side of the figure. The brain cannot overlook the length of the sides when evaluating the areas of the shapes, and the perceived areas are frequently relative, despite our attempt to interpret them as absolute.

The illusion is often observed in the real world. For example, when two curving toy railway tracks are kept vertically, the lower one looks larger, even though they are identical. However, one area where the illusion is often overlooked is in the fonts of Indic scripts. In comparison to Latin scripts, Indic scripts have a lot more curves. Because of their origins, the characters have these curved structures. These characters were inscribed on palm leaves, which had vertical fibres. These vertical fibres made writing with straight strokes extremely difficult as the palm leaf would tear from the direct force applied by the writing instruments. The Odia script may find the Jastrow illusion in numerous places, which is one of the scripts with similar beginnings. Some examples are illustrated below.

The image below exhibits the letter 'La' in Odia. The letter is typed in the font Noto Sans Odia by Google's Noto project. The line above the letter is the diacritic sign of 'e.' This is an excellent example of the Jastrow illusion becoming prominent as the type of font differs (thin, regular, or black). Even though the letter is written in the same font, the accent seems smaller and heavier than the alphabet itself as the thickness increases.

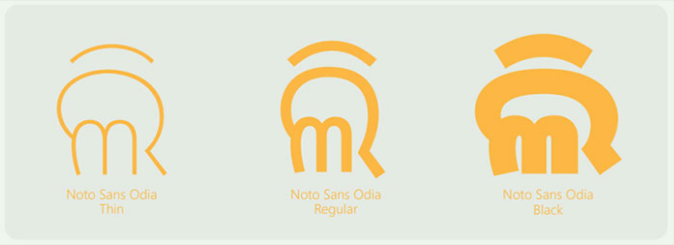

Figure 7.3.f
Source: Amit Patjoshi

One explanation for the illusion provided previously is the presence of a stark contrast between the shorter and the longer side. Therefore, the longer side seems to be much longer and vice versa. This concept of Jastrow illusion can also affect the perceived size of curves in characters with two or more curves. Even if the curves are of different sizes, the example below explores the size perception of these curves concerning their positioning. The Odia letter' ଚ' (ca) has two curves on top of each other.

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As seen in the example below, positioning the larger curve below the circle makes it seem much larger than when positioning the larger curve above the circle. When a smaller circle is placed above the larger curve, we have a reference point of how small the circle is; therefore, we tend to judge the curve to be larger than it is. Because as the smaller side of the top curve interacts with the lower circle, it needs to be made larger to look normal-sized.

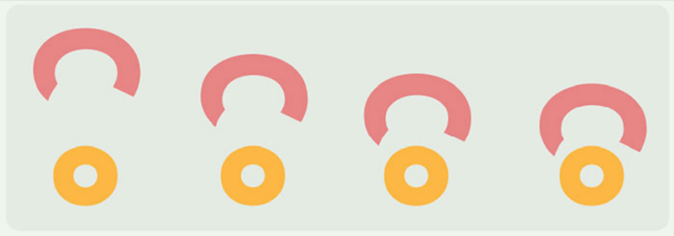

Figure 7.3.g
Source: Amit Patjoshi

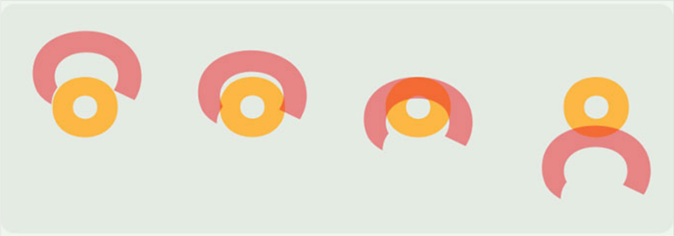

Figure 7.3.h
Source: Amit Patjoshi

The width of the top curve is affected by the weight of the letters. These letters are written between the cap height and the baseline, and the lower circle and upper circle are drawn at the same height. When the letter weight is increased, the weight in the bottom circle and the top curve on the inner side increases. Behind each letter, transparent red boxes of the same width indicate how the top curve is subtly widened to counter the illusion.

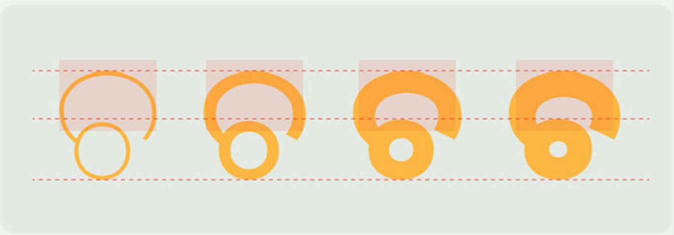

Figure 7.3.i
Source: Amit Patjoshi

Unlike the above letter’ ଚ’ (ca), which has a direct interaction with the curves, letters like ‘ଞ’ (nya) have the same form that is repeated in its formation. There are additional elements in this letter other than the curve. Therefore, to achieve balance, the lower part of the letter is made a little bit larger. Jastrow’s illusion in this example seems to hinder the balance of a letter. Therefore, the lower part has to be modified to counter the illusion and achieve a sense of balance.

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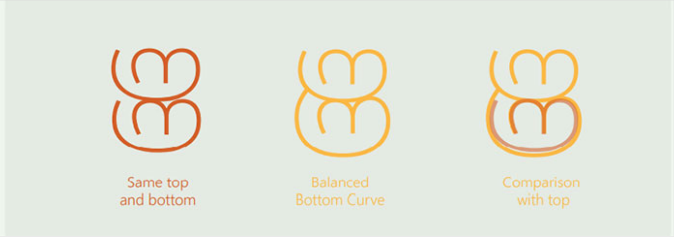

Figure 7.3.j
Source: Amit Patjoshi

One can notice the difference in the curve in other weights. Interestingly, as the letter becomes heavier, the difference gradually decreases.

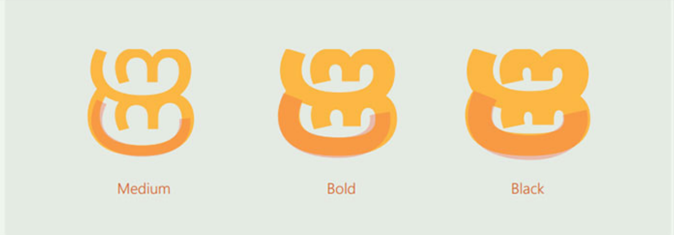

Figure 7.3.k
Source: Amit Patjoshi

Some letters, such as the letter' ଭ' (bha), also have the effect of a curve branching out. Although the curves are not the same size as the original illusion, the illusion persists in the impression of their relative sizes. As shown in the investigations below, the difference in size perception between 1 and 2 is astounding.

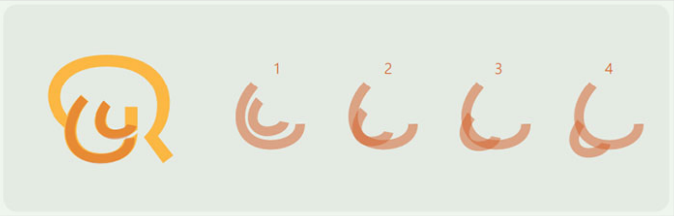

Figure 7.3.l
Source: Amit Patjoshi

Similarly, the graphic below depicts the Odia letter 'La' with two different signs: the vowel sign 'e' and 'Chandra Bindu.' The Chandra Bindu appears to be substantially smaller at first glance. However, as we flip the 'e' sign, they seem to be about the same length.

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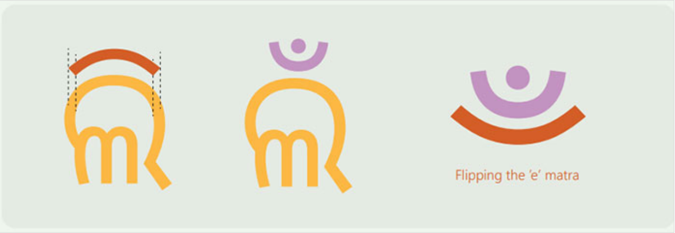

Figure 7.3.m
Source: Amit Patjoshi

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7.4 Delboeuf Illusion

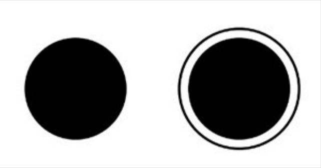

Figure 7.4.a
Source: Dishant Mehlawat

Would you say the black circles in the picture above are the same size? Doesn't it look like the circle on the right is slightly bigger than the circle on the left? This is the Delboeuf illusion, and it involves size perception. It was described in 1865 by the Belgi Joseph Remi Leopold Delboeuf. In the Delboeuf illusion, the presence of a bigger concentric circle can alter the perception of the size of a target circle. In other words, when two circles of the same size are placed next to one another, and one of the circles is surrounded by a concentric ring, there will be a difference in the size perception of the two circles due to the presence of the larger ring (Figure 7.4.a).

The size disparity between the inner and outer circle produces various effects. There are two factors for this illusion: assimilation and contrast. One may overestimate the target's size if the outer circle is slightly larger than the target; this is known as size assimilation (Figure 7.4.c). However, one will underestimate the target circle if the outside circle is much larger than the target circle; this is known as size contrast Figure 7.4.b).

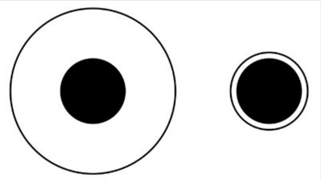

Figure 7.4.b
Source: Dishant Mehlawat

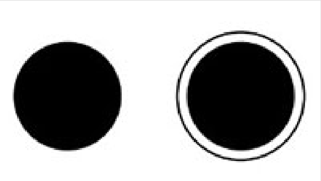

Figure 7.4.c
Source: Dishant Mehlawat

Why does this illusion take place?

Delboeuf offered one potential explanation in 1865. Delboeuf suggested that the eyes are physically moved over a greater distance when scanning the inner circle because they are drawn to the outer circle when it is close to the inner circle. The size of the central circle is perceived differently due to the eyes' increased muscular effort. The Delboeuf illusion provides an understanding of visual correction required for designing typefaces.

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Here are some explorations of the Delbouef illusion using Latin alphabets.

In Figure 7.4.d, two lowercase 'A's are placed next to each other. One on the right is edited, where the stem is made bolder. But the counter of both the 'A's look similar, and the Delboeuf illusion cannot be observed.

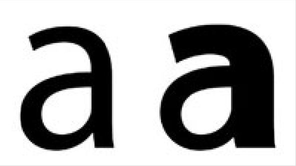

Figure 7.4.d
Source: Dishant Mehlawat

Similarly, in Figure 7.4.e, two lowercase 'A's are placed next to each other. One on the right is edited, and the stem and terminal are both made bolder. The counter of the 'A' on the right looks smaller because of the Delboeuf illusion.

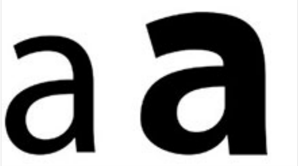

Figure 7.4.e
Source: Dishant Mehlawat

In Figure 7.4. f, all the glyphs of the 'A' on the right-hand side are made bolder, and the counter looks smaller.

Increasing the boldness of the strokes causes an underestimation of the counters in Latin alphabets, given that the stroke width increases without affecting the counter size.

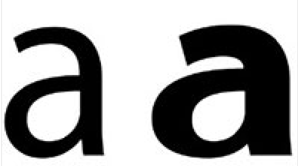

Figure 7.4.f
Source: Dishant Mehlawat

In Figure 7.4.g, two lowercase 'D' are placed next to each other. One on the right is edited, where only the stem is made bolder. But the counter of both the a's look similar, and Delboeuf illusion cannot be observed.

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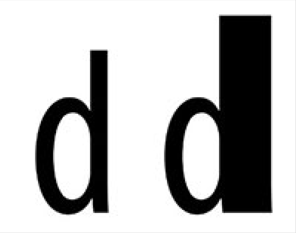

Figure 7.4.g
Source: Dishant Mehlawat

Similarly, in Figure 7.4.h, two lowercase 'D' are placed next to each other. One on the right is edited, where the stem and bowl are made bolder. The counter of the 'A' on the right looks smaller because of the Delboeuf illusion.

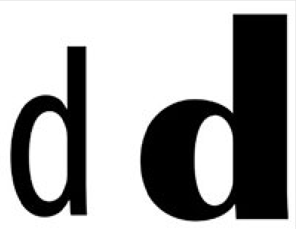

Figure 3.5.5.h
Source: Dishant Mehlawat

In Figure 7.4.i, two 'O's are placed next to each other and their apertures are unconventional. One on the right is edited and made bolder. Even after having an abstract shape as a counter, the counter of the 'O' one on the right side looks smaller, and the Delboeuf illusion can be observed.

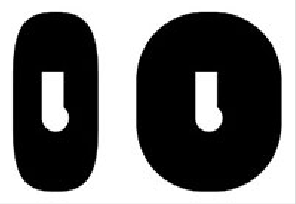

Figure 7.4.i
Source: Dishant Mehlawat

Interestingly in Figure 7.4.j, the Delboeuf illusion can be observed by increasing the stroke width, but the counter of the 'O' on the right side looks elongated, whereas the size of both the counters is equal.

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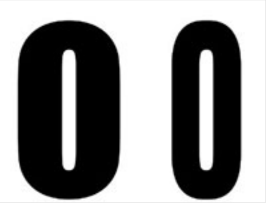

Figure 7.4.j
Source: Dishant Mehlawat

In Figure 7.4.k, two 'O's are placed next to each other. The 'O's are calligraphic and have contrasting stroke widths. One on the right is edited and made bolder. Even after contrasting stroke width, the counter of the 'O' one on the right side looks smaller, and the Delboeuf illusion can be observed.

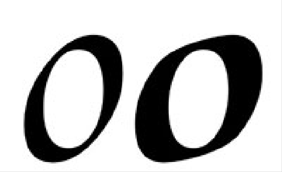

Figure 7.4.k
Source: Dishant Mehlawat

Here is another example of the Delboeuf illusion when an intentional slant of 12° is added to the 'O' (Figure 7.4.l).

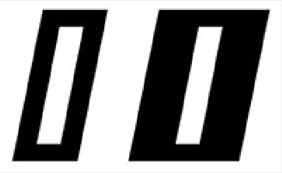

Figure 7.4.l
Source: Dishant Mehlawat

In Figure 7.4.m, two dotted 'D' are placed next to each other. One on the right is made bolder. But here, the counter looks exactly similar because we can count the small circles that form the counter, forcing our brains to think more logically and eliminating any illusion.

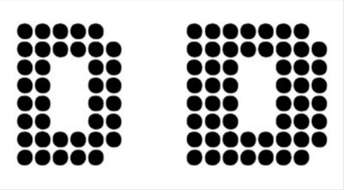

Figure 7.4.m
Source: Dishant Mehlawat

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In Figure 7.4.n, two' D' made out of lines are placed next to each other. One on the left is made up of more lines than the 'D' on the right, making it look much denser and bolder. The increased density of the 'D' on the right makes the counter look smaller, and the Delboeuf illusion can be observed.

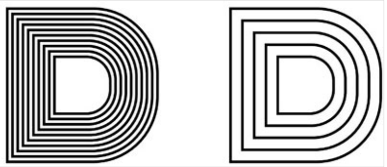

Figure 7.4.n
Source: Dishant Mehlawat

Here are some explorations with Devnagari characters

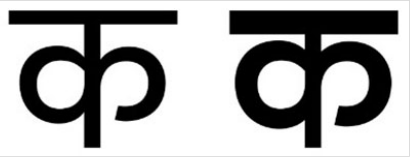

Figure 7.4.o
Source: Dishant Mehlawat

In Figure 7.4.o, two 'क's are placed next to each other. One on the right is edited, and the Sherorekha and the stroke width are increased. The counter and aperture of the 'क' on the right look smaller because of the Delboeuf illusion.

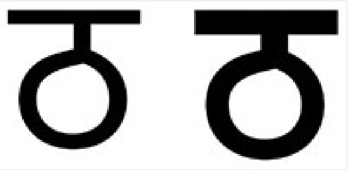

Figure 7.4.p
Source: Dishant Mehlawat

Similarly, in Figure 7.4.p, two' ठ's are placed next to each other. One on the right is edited, and the Sherorekha and the stroke width are increased. The counter of the 'ठ' on the right looks smaller because of the Delboeuf illusion; however, they are similar in size.

Please look at the pdf below to learn more about these explorations:
- Delboeuf Illusion......

Design Course
Visual Perception for Communication Designers
Human Factors and Sociotechnical Systems Studios
by
Vivek Kant and Sruthi Sridhar
IDC, IIT Bombay

Source:
https://www.dsource.in/course/visual-perception-communication-designers/7-size-and-distance/75-oppel-kundt-illusion

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7.5 Oppel Kundt Illusion

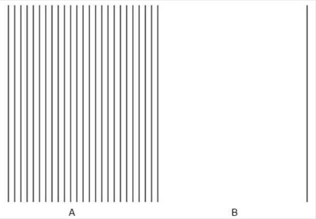

Figure 7.5.a
Source: Midhun Mohan

Would you say that the distance covered by segment A is the same as that of segment B in Figure 7.5.a? Most people would judge the blank segment to be smaller/shorter compared to the line-filled part. This is the Oppel-Kundt illusion (OKI). Oppel-Kundt illusion can be described as a section of visual field broken up into /filled with several visual components that appears larger than an undivided space of equivalent size. They are helpful when thinking about designing grids and optical correction.

Even though the illusion is termed the Oppel-Kundt illusion, history suggests otherwise. Neither J.J. Oppel nor A. Kundt discovered the illusion as we know it today. Kundt did not discover the illusion but was likely the first to investigate it quantitatively. Oppel described a phenomenon comparable but not identical to the form of the OKI observed today. Several distinct writers are responsible for the stimulus figure's reduction to a one-dimensional array of visual components, which became the OKI known today.

Let us study the illusion in detail, try to understand how it works and explore how changes in characteristics of the filled and unfilled spaces affect the illusion created.

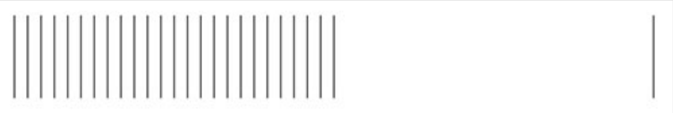

Figure 7.5.b
Source: Midhun Mohan

Look closely at the two spaces shown in Figure 7.5.b. One can see that the space on the left is filled with lines while the right is unfilled. Are both the spaces equal or does one appear larger than the other?

First, let us construct similar spaces by dividing space in half and filling one of the halves to find roughly when the illusion becomes apparent.

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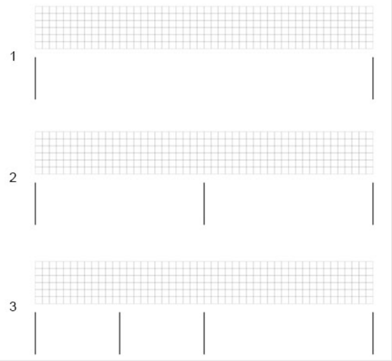

Figure 7.5.c
Source: Midhun Mohan

As can be seen in Figure 7.5.c, the illusion is not apparent in steps 1, 2, and 3. However, the illusion becomes evident from step 4 and gets stronger as the space is divided/filled even further (until 9).

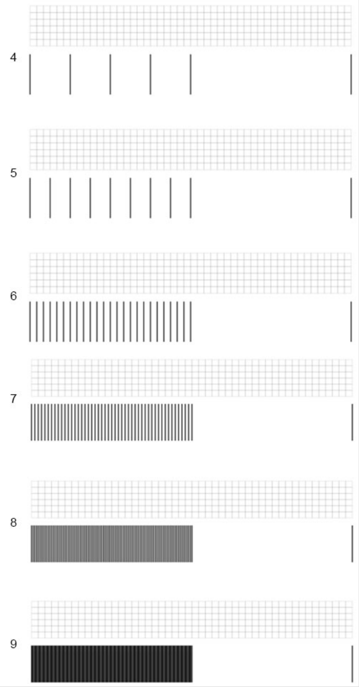

Figure 7.5.d
Source: Midhun Mohan

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There have been several explanations for the phenomenon, but none thoroughly explain the illusion. The most compelling explanation was provided by H.G. Speigel (1937). He suggested that the illusion resulted from an attractive “Z- force” acting between visual field objects with similar appearances, balanced by an opposing repulsive force between objects that are interpolated. According to this view, the impact results from the “shrinking” of the empty part relative to the unfilled part. Instead of operating on a peripheral (retinal) level, Spiegel proposed that the organizing “forces” operate in the central (cortical) representation.

Apart from the various explanations, from a designer’s perspective, what are the components of making a robust OK illusion? Below, these various elements are explored. These explorations include spaces of varying lengths and heights that are created to understand their effect on the illusion.

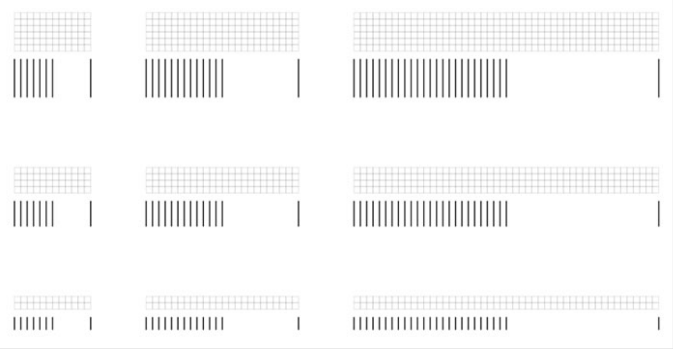

Figure 7.5.e
Source: Midhun Mohan

As seen in Figure 7.5.f, the illusion becomes more evident when the length of the spaces is decreased. Also, the illusion appears to get weaker when the height of the spaces is reduced.

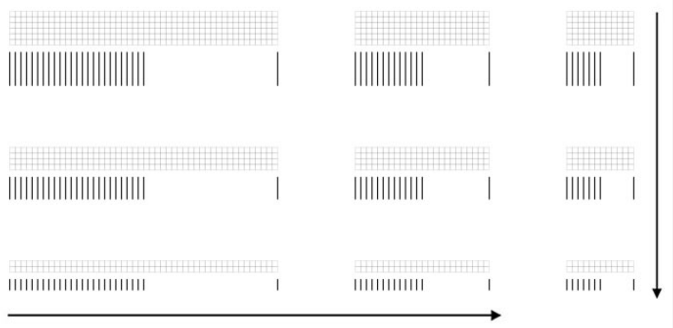

Figure 7.5.f
Source: Midhun Mohan

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What if we optically balance the two spaces? Let us understand how much optical correction needs to be done so that the two spaces appear to have the same length (Figure 7.5.g).

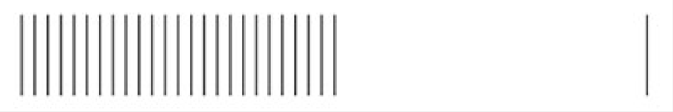

Figure 7.5.g
Source: Midhun Mohan

Visual adjustment added is highlighted in yellow in Figure 7.5.h.

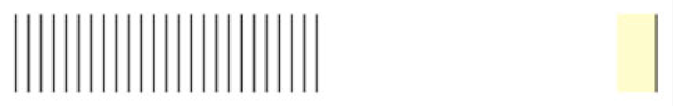

Figure 7.5.h
Source: Midhun Mohan

As shown in Figure 7.5.i, adding an adjustment roughly equivalent to the length highlighted appears to balance the filled and unfilled spaces.

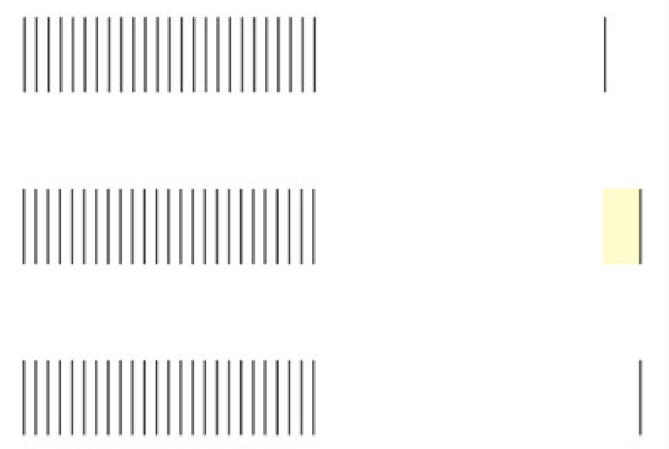

Figure 7.5.i
Source: Midhun Mohan

What happens when the space is divided horizontally compared to vertical divisions?

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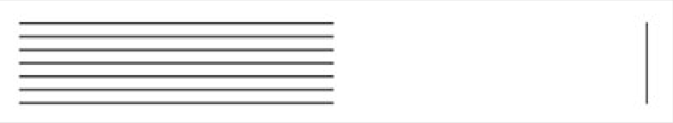

Figure 7.5.j
Source: Midhun Mohan

The illusion persists even when the space is divided horizontally. Let's try to visually balance the spaces created.

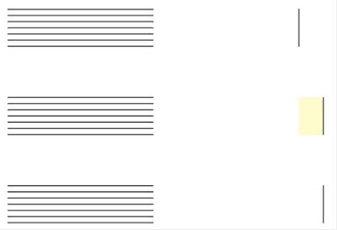

Figure 7.5.k
Source: Midhun Mohan

As shown in Figure 7.5.k, visually balancing both spaces would require optical adjustment in length, as highlighted here. What about a different direction of lines being filled?

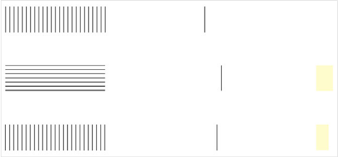

Figure 7.5.l
Source: Midhun Mohan

Interestingly, the optical adjustment required for horizontal subdivisions is slightly more than that of vertical divisions. What happens when the space is filled in with different styles?

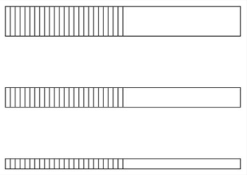

Figure 7.5.m
Source: Midhun Mohan

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When both spaces are well defined with a boundary, the illusion seems to be reduced (Figure 7.5.m).

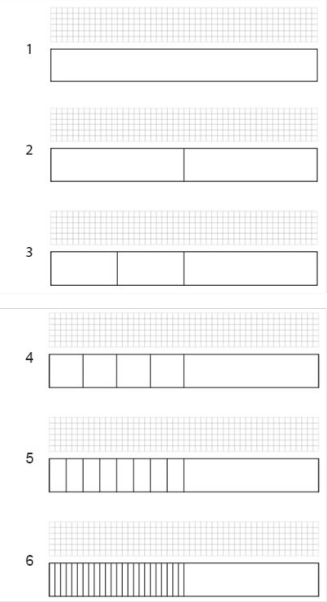

Figure 7.5.n
Source: Midhun Mohan

This is an interesting case since the strength of the illusion is vastly reduced when a boundary wall defines the spaces. Let us again construct the spaces with defined boundaries and try to identify the point where the illusion becomes apparent. As can be seen in Figure 7.5.n, the illusion becomes somewhat evident in step 5 and gets stronger in step 6. But there is a twist!

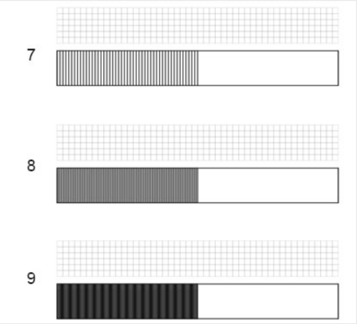

Figure 7.5.o
Source: Midhun Mohan

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The illusion appears to weaken as the space is further filled and closer to a solid fill state (Figure 7.5.o). What happens when the space is filled in with a solid colour?

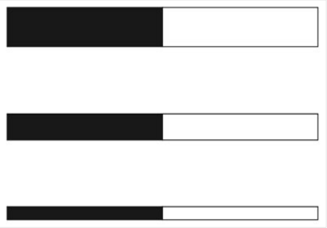

Figure 7.5.p
Source: Midhun Mohan

When one of the spaces is given a solid fill, and an outline bounds the unfilled space, the illusion seems to be reduced to such an extent that it is almost non-existent. What if even the "empty" space is filled with colour?

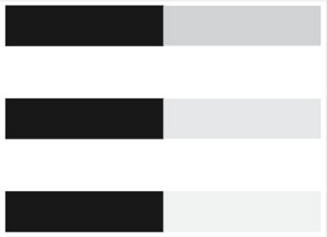

Figure 7.5.q
Source: Midhun Mohan

When both spaces are given a fill, the higher value side can be considered as the unfilled space. The length of such an unfilled space appears to get longer as it gets lighter (increased value).
What happens when the space is filled in different styles?

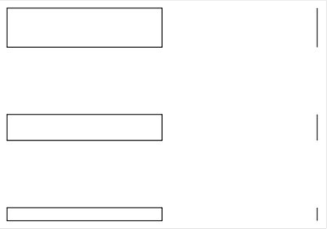

Figure 7.5.r
Source: Midhun Mohan

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Here, again the illusion comes into play, and the space on the left appears longer. The same happens when the space is given a solid fill (Figure 7.5.s).

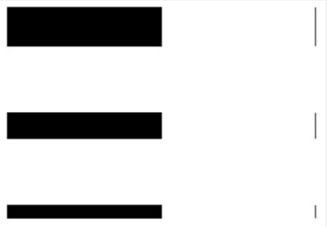

Figure 7.5.s
Source: Midhun Mohan

What if it is filled with a pattern?

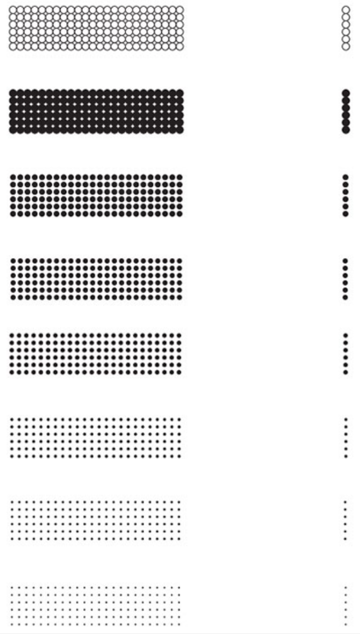

Figure 7.5.t
Source: Midhun Mohan

This exploration uses uniform patterns to divide and fill the space. As one can see here, using patterns as fill doesn't seem to have much effect on the illusion. The unfilled space might appear to be getting progressively longer as the size of dots in the pattern becomes smaller.

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The various types of 'fills' can be seen to vary the strength of the illusion. For example, the illusion seems to reduce when the space boundaries are more defined in ways such that it gives more visual cues for our eyes to pick up the length of spaces more strongly.

What effects do different types of gradation to the fill bring to the illusion?

The illusion is present when the gradation is even or uneven. But as the gradation becomes more irregular and starts having larger gaps (which makes it look less filled), it affects the illusion. The more 'unfilled' the filled space appears due to gradation, the weaker the illusion gets.

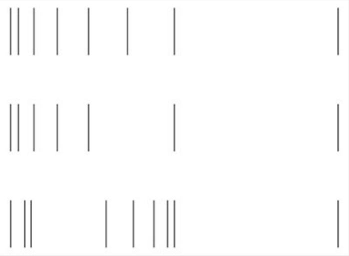

Figure 7.5.u
Source: Midhun Mohan

What if the thickness of the gradation is increased or decreased?

In this case, depending on the direction of uniform gradation, the unfilled space may appear longer or shorter than the unfilled space in the example without gradation.

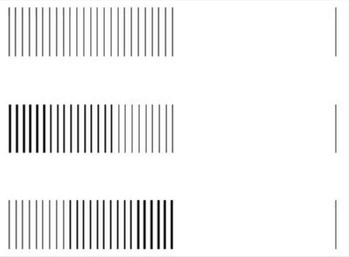

Figure 7.5.v
Source: Midhun Mohan

What if the filled space is non-uniform?

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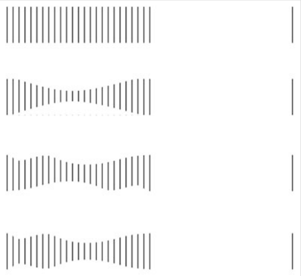

Figure 7.5.w
Source: Midhun Mohan

The illusion is still present when the filled space is non-uniform.

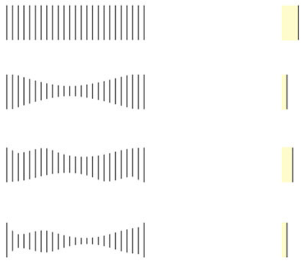

Figure 7.5.x
Source: Midhun Mohan

The optical correction added to balance the two spaces are found to be lesser when the filled space is non-uniform (Figure 7.5.x).

What will happen when the starting and ending of both spaces are more defined?

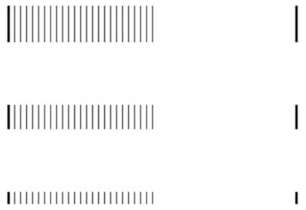

Figure 7.5.y
Source: Midhun Mohan

Defining the two extreme ends of the overall space does not seem to make much difference (Figure 7.5.y).

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Let's take it a step further and define the centre where the two spaces meet (Figure 7.5.z).

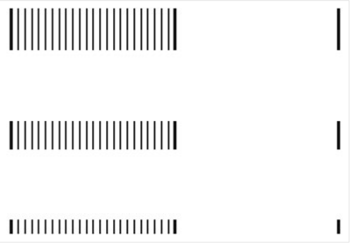

Figure 7.5.z
Source: Midhun Mohan

In this case, the spaces appear to create confusion regarding the filled space being longer or if they are equal. Yet, it is more probable that one might find the filled space to be longer.
What about the orientation of the entire segment? Will that affect the illusion?

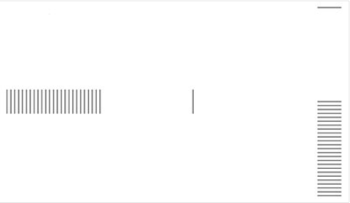

Figure 7.5.za
Source: Midhun Mohan

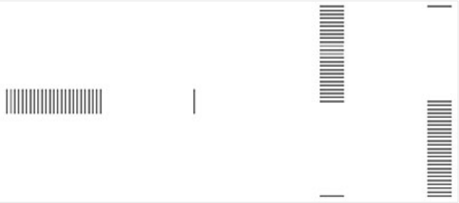

Figure 7.5.zb
Source: Midhun Mohan

The illusion can be seen when the spaces are in a vertical orientation. One interesting thing to notice is that the unfilled space in vertical orientation appears to be longer than the horizontal.
Then what about when the positions of filled and unfilled spaces are reversed? Does the unfilled space look smaller when it is at the bottom than when it is at the top?

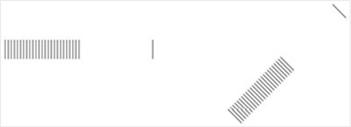

Figure 7.5.zc
Source: Midhun Mohan

Diagonal orientation does not affect the illusion much, as seen here.

One can download the complete set of explorations here:
- Oppel Kundt Illusion......

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7.6 Forced Perspective

In order to understand the concept of forced perspective, we have to revisit the idea of the normal perspective. In everyday life, this is how you would perceive perspective. In the figure below of the corridor, one can observe the everyday perspective due to the size decreasing as one moves towards the converging point.

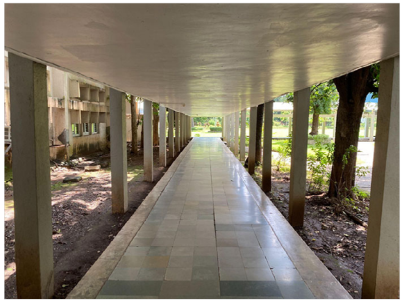

Figure 7.6.a
Source: Vivek Kant

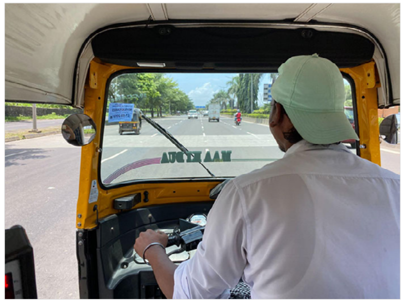

Figure 7.6.b
Source: Vivek Kant

We see a similar case with the view from the auto-rickshaw. The size of the vehicles decreases as we move away from the beholder. Also, the lines on the road converge towards the horizon. However, in many cases, the size and distance can be entwined in a unique relationship. Artists have often done this by using forced perspective.

Recreating Forced perspective

Would you say that these dogs are of different sizes?

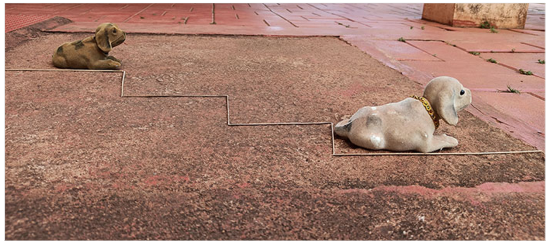

Figure 7.6.c
Source: Shraddha Prabhu

The dog on the left looks smaller than the dog on the right. However, would you believe me if I said that these dogs are the same size? This illusion in everyday life is inspired by the ones created by the artist Amy Arnston Marein's* work.

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*Behrens, R. R. (1987). The Life and Unusual Ideas of Adelbert Ames, Jr. Leonardo, 20(3), 273-279.

The dog on the left looks smaller than the dog on the right. However, would you believe me if I said that these dogs are the same size? We perceive them to be different sizes because of their placement. The dog on the left is placed further back than the dog on the right. The two identically sized dogs are placed at different distances. The white dog looks bigger because it is closer (size-distance scaling). The sticks on the ground are also used to connect the two dogs, giving the impression that they are being rested on a set of steps. A forced perspective is created by the sticks’ length, thickness, alignment, and spacing. However, the ground’s gradient and the vanishing point of the pavement blocks act as depth cues that reveal the illusion. In the exploration below, the depth cues have been eliminated by using a black background.

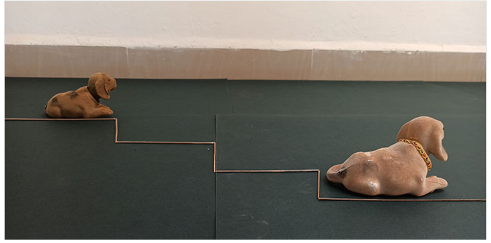

Figure 7.6.d
Source: Shraddha Prabhu

This elimination enhances the forced perspective-induced size distance illusion. Since the sticks at the back appear smaller and thinner, each stick’s length and thickness are gradually raised to create a forced perspective. Additionally, the distances between the sticks have been widened. Also, the sticks are not perpendicular to one another. The angles have been altered to achieve the necessary vanishing point.

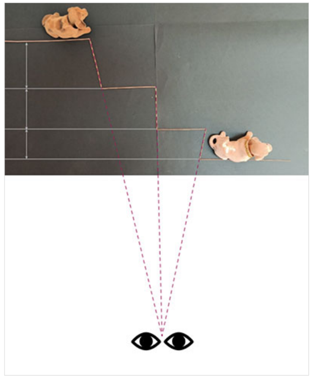

Figure 7.6.e
Source: Shraddha Prabhu

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Visual Perception for Communication Designers

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by
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IDC, IIT Bombay

Source:
https://www.dsource.in/course/visual-perception-communication-designers/7-size-and-distance/76-forced-perspective

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Some of the sticks can be placed vertically, perpendicular to the ground, to create a more convincing illusion.

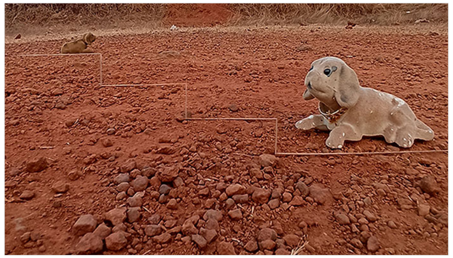

Figure 7.6.f
Source: Shraddha Prabhu

The side view demonstrates how the sticks were positioned to distort perspective. The length and thickness of the sticks steadily expand as you go closer to the brown dog, as does the space between them, giving the front view the illusion of a flight of stairs.

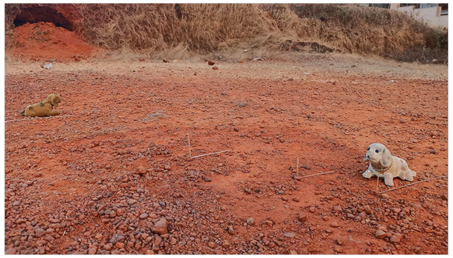

Figure 7.6.g
Source: Shraddha Prabhu

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8. Depth and Perspective

8.1 Depth Perception

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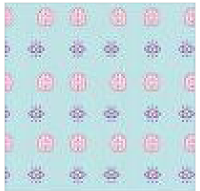
8.3 Impossible Figure


8.4 Autostereogram

8.5 Ames Room Illusion

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8.1 Depth Perception

Did you ever get the chance to enjoy watching a 3D movie in the theatres? How do you think the movie experience is created? One of the most significant determining factors of the 3D movie experience is artificially created depth cues. Depth perception is the ability to see the world in three dimensions. It’s a valuable innate skill as one would struggle to judge how far away items are without them. Designers and moviemakers often use depth cues, such as VR, to manipulate the viewing experience. There are numerous cues for sensing depth in the world. Some require only one eye (monocular cues), while others result from different visual patterns that occur when both eyes are utilized (binocular cues).

Monocular Cues
Artists have finely developed the depiction of depth in pictures. Often, they use “monocular cues” to create the appearance of depth in paintings and drawings. As a result, these are commonly referred to as pictorial depth cues. Below are some examples of these monocular cues.

Linear Perspective: This is the most common depth cue widely used in photographs and pictures. The tendency for parallel lines to converge on one another is known as linear perspective. For example, when staring down a straight highway, the two sides of the road appear to converge in the distance (as seen in the image below). It works in a picture because people assume that the converging lines, like in real life, suggest that the “endpoints” of the lines are far from where the individuals are viewing them.

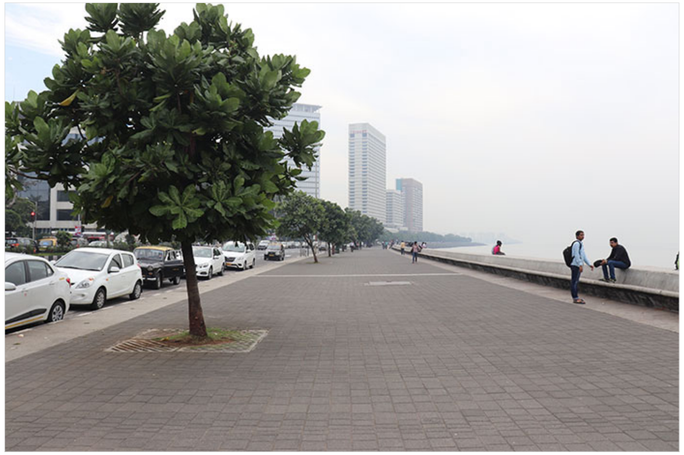

Figure 8.1.a
Source: Sravan Sridhar

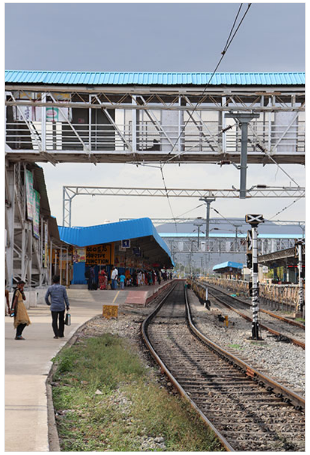

Figure 8.1.b
Source: Sravan Sridhar

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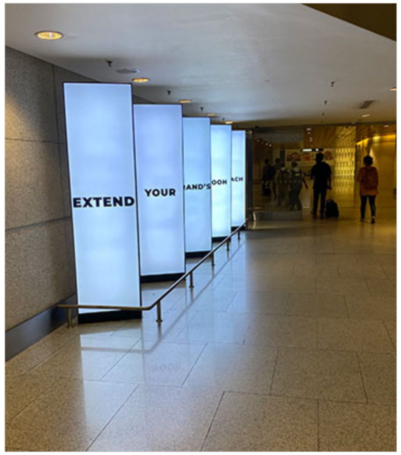

Figure 8.1.b1
Source: Vivek Kant

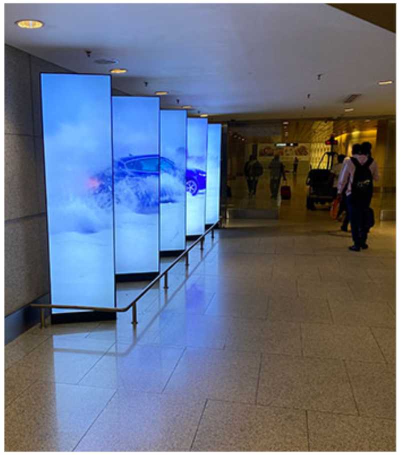

Figure 8.1.b2
Source: Vivek Kant

Relative Size: When going through photographs, you may subconsciously judge one entity in the picture to be bigger than the other. Relative size is used as a depth cue when items that people expect to be a specific size appear small and are therefore considered farther away. In other words, we subconsciously expect the smaller size entities to be in front whereas larger size entities to be further from us. Filmmakers use this approach to make their small models appear enormous from afar. In the image below, we make the judgment of how far away the sheep is based on the size of the sheep. The larger the sheep, the closer it appears to us or the camera.

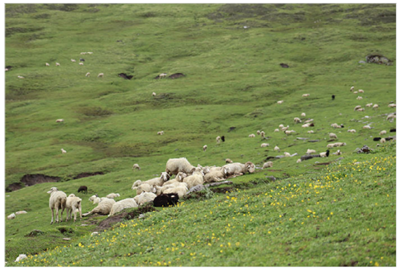

Figure 8.1.c
Source: Sravan Sridhar

Interposition: People assume that if one object appears to be blocking another, the obstructed object is behind the first and hence further away in terms of distance. This is used as a cue by both photographers and movie-makers. Overlap is another name for this cue. For example, in the picture below, one will never assume the grass is closer to the camera than the tent blocking the view.

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Figure 8.1.d
Source: Sravan Sridhar

Aerial Perspective: Due to microscopic particles of dust, dirt, and other impurities in the air, the farther away an item is, the hazier it appears. This leads to a perceptual cue known as aerial (atmospheric) perspective. This is why far mountains appear fuzzier than nearby ones, and distant buildings appear blurrier than nearby ones. This cue is used quite often by artists in showing landscapes and hills.

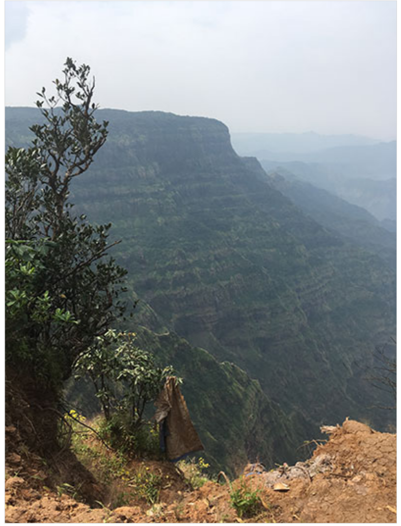
Figure 8.1.e
Source: Sravan Sridhar

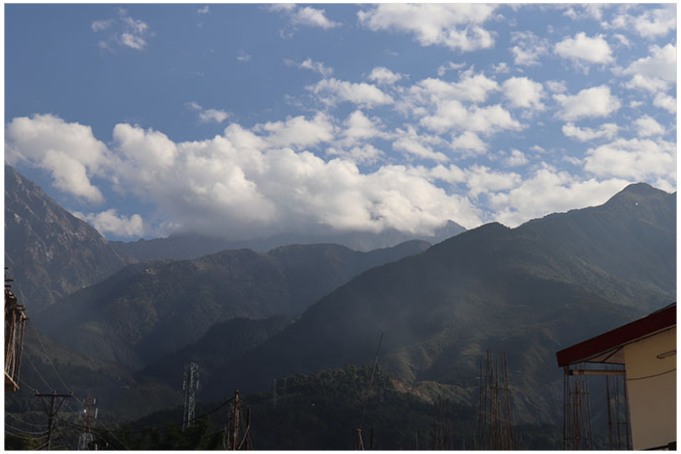
Figure 8.1.f
Source: Sravan Sridhar

Texture Gradient: Look at any vast stretches of pebbles, rocks, or patterned roadways (such as a cobblestone street) nearby. The texture of the stones or bricks closest to you is quite apparent, but as you stare further away, the texture appears smaller and finer. Another technique artists employ to create depth in a painting is textural gradient. The texture explains how the gradient is laid out, making things appear far or near. It can be quite effectively used to create a semblance of distance and is used quite often by artists.

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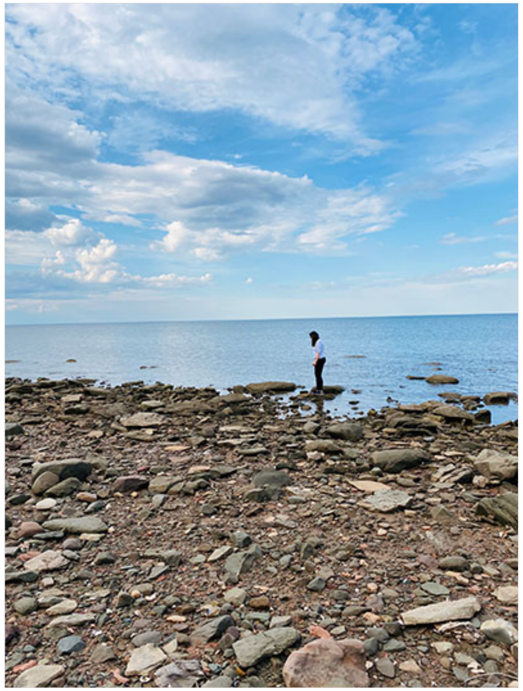

Figure 8.1.g
Source: Muhammed Azlam

Motion Parallax: Finally, the motion also provides an insight into depth. When you're next in a car, note how objects in proximity to the car seem to move very quickly, while those in the distance, such as mountains, appear to move more slowly. Motion parallax is the difference in motion between near and distant objects. Motion is used quite effectively in old-style movies, especially in car sequences involving chase, where they would show people driving. In these sequences, you would see the car moving with the background screen where there is a projection of moving cityscapes.

Binocular cues: Apart from the monocular cues, which could still work out in the case of one eye, binocular cues are possible only with two eyes.

Convergence: The two eyes are rotated to focus on a single object in their sockets. This rotation to focus is known as convergence. The convergence is high if the object is close (almost as much as eyes crossing). Convergence is substantially less if the object is far away. Move your finger away and back while holding it up in front of your nose. Convergence is the sensation you get in your eye muscles.

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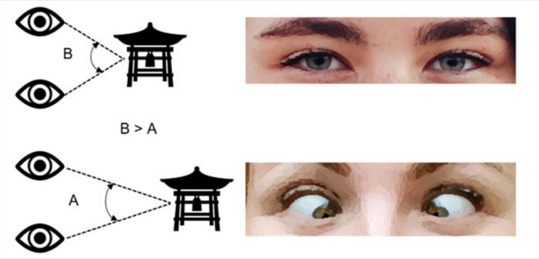

Figure 8.1.h
Source: Sruthi Sridhar. Recreated from Ciccarelli and White, 2018 (page 165)

The eye muscles are more relaxed when an object is far away; when an object is close, the eye muscles move closer together or converge.

Binocular Disparity: Binocular disparity describes how the eyes do not view the same image because they are a few inches apart. The brain perceives the image on the retina to determine distance from an individual. The object must be reasonably close if the two photos are that different. If they're almost similar, the object is far enough away for the retinal discrepancy to be negligible. Holding an object in front of your nose can help you display this cue. Close one eye and note the object's location, then open that eye and close the other. There should be a significant gap in viewpoints. When you perform the same thing with an object across the room, the image doesn't appear to "jump" or move as much, if at all.

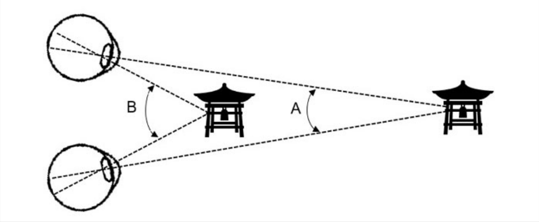

Figure 8.1.i
Source: Sruthi Sridhar. Recreated from Ciccarelli and White, 2018 (page 165)

The critical idea in binocular disparity is as follows. The difference in A is negligible since the item is far enough away. While the item is closer in B, the disparity between what each eye sees is higher. The brain interprets this difference as the object's distance.

In most cases, many size-distance and depth cues act together to provide a full-blown experience. In the examples below in this section, we explore examples dealing with perspective, size, depth, and distance.

Source:
https://www.dsource.in/course/visual-perception-communication-designers/8-depth-and-perspective/82-anamorphosis

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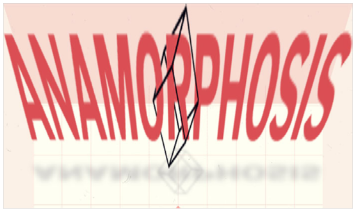


Figure 8.2.a
Source: Alen Antony Francis

The picture above appears to be a two-dimensional distorted version of the word anamorphosis. Would you believe me if I said I could make the same image look three-dimensional when printed on paper? If we print this out and keep the paper perpendicular to our eyesight and look at the word, it will appear to be a 3-dimensional figure, just like the picture below. This is the anamorphic illusion, where our brain misconceives depth to form a three-dimensional image. What exactly is anamorphosis? And how does our brain perceive a two-dimensional picture to be three-dimensional?

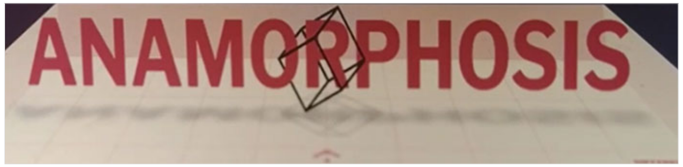
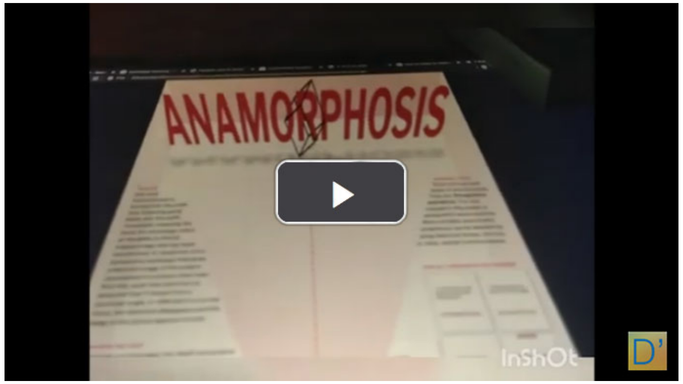


Figure 8.2.b
Source: Alen Antony Francis



Source: Alen Antony Francis

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Anamorphosis is a distorted projection or perspective that requires the observer to stand at a precise location or employ special equipment to reconstruct the image. Anamorphosis originates from the Greek word Ana which means "back or again," and Morph, which means "form or shape"; the term loosely translates to "formed again." Two common types of anamorphosis are perspective (oblique) and mirror (catoptric) anamorphosis. Perspective anamorphosis dates to the early Renaissance (15th century), while mirror anamorphosis was prominent throughout the Baroque period in art (17th century).

The example above is of a perspective anamorphosis that requires proper positioning of the observer to gain the correct viewpoint to see the unformed version of the image. A conical or cylindrical mirror must be positioned over a drawing or painting on a planar surface to change a flat distorted image into a three-dimensional picture that individuals can view from various angles to produce a mirror-anamorphic image. The picture will appear undeformed when you look into the mirror at a unique angle.

Perspective forms of anamorphic images are typically ambiguous figures because while one can mislead individuals into perceiving the anamorphic images as 3D, they most often appear as distorted 2D images. The perspective forms must be seen from a particular angle for this illusion to work. The anamorphic illusion brilliantly displays the fact that the light that falls on our retina, and the following visual experience, can be created by different arrangements of objects and attributes in the environment around us. In the case of anamorphic pictures, we can see what appears to be a 3D picture (which the anamorphic image deceives us into thinking) and what is actually there at various moments (the 2D picture).

In the distorted version of the picture above, the word anamorphosis is distinct and identifiable when it is 2D. However, it is somewhat challenging to identify the cube-shaped around the "O" and "R." The cube shape becomes undistorted when looked at from the correct viewpoint. This phenomenon can be explained by two theories: shape constancy and linear perspective. Our brains continually interpret and shape the raw visual data from our eyes. We prefer a well-ordered environment with recognizable forms and predictable patterns. According to the Gestalt school of psychology, one of the characteristics of human perception is that our brain prefers to organize visual elements in a regular, ordered, symmetrical and simple manner. As a result, we observe stable rectangular forms whenever possible, even if these forms are deformed most of the time due to perspective projection and are continually changing due to our movement. This idea is referred to as shape constancy.

To observe an anamorphic picture, one must first convert an oblique and non-uniform focus plane into a cohesive, 2D image, which can be aided by viewing it with one eye or half-closed eyes. This allows the picture to be separated from the screen or supporting surface, allowing the anamorphosis to re-form. Normal images are not warped when viewed from an oblique angle because human perception can immediately correct the distortion using the shape constancy principle. However, moving away from an anamorphic image's correct viewpoint can swiftly diminish the illusion.

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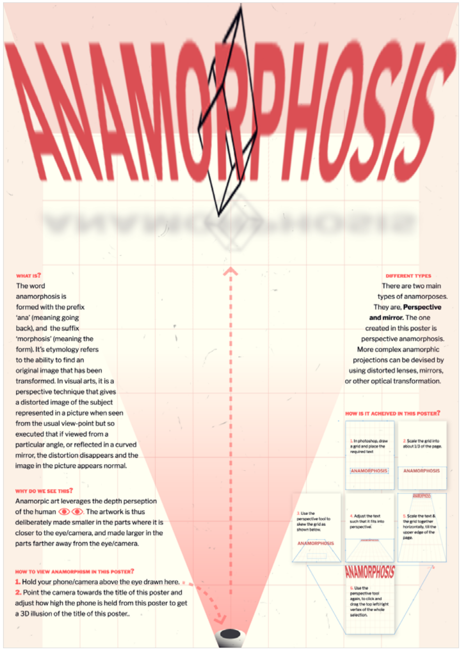

ANAMORPHOSIS

WHAT IS?
The word anamorphosis is formed with the prefix 'ana' (meaning going back), and the suffix 'morphosis' (meaning the form). It's etymology refers to the ability to find an original image that has been transformed. In visual arts, it is a perspective technique that gives a distorted image of the subject represented in a picture when seen from the usual view-point but so executed that if viewed from a particular angle, or reflected in a curved mirror, the distortion disappears and the image in the picture appears normal.

WHY DO WE SEE THIS?
Anamorpic art leverages the depth perseption of the human 👁👁. The artwork is thus deliberately made smaller in the parts where it is closer to the eye/camera, and made larger in the parts farther away from the eye/camera.

HOW TO VIEW ANAMORPHISM IN THIS POSTER?
1. Hold your phone/camera above the eye drawn here.
2. Point the camera towards the title of this poster and adjust how high the phone is held from this poster to get a 3D illusion of the title of this poster..

DIFFERENT TYPES
There are two main types of anamorposes. They are, **Perspective and mirror.** The one created in this poster is perspective anamorphosis. More complex anamorphic projections can be devised by using distorted lenses, mirrors, or other optical transformation.

HOW IS IT ACHEIVED IN THIS POSTER?
1. In photoshop, draw a grid and place the required text
2. Scale the grid into about 1/3 of the page.
3. Use the perspective tool to skew the grid as shown below.
4. Adjust the text such that it fits into perspective.
5. Scale the text & the grid together horizontally, till the upper edge of the page.
6. Use the perspective tool again, to click and drag the top left/right vertex of the whole selection.

Figure 8.2.c
Source: Alen Antony Francis

Moreover, according to the classical linear perspective, light travels in straight lines, and when light reflected from an item intersects a planar surface, it reflects an exact depiction of the original object. While humans commonly view pictures frontally from a narrow range of viewing angles, the observer of an anamorphic image must typically be at a radically oblique angle to the image plane (in this case: perpendicular to the eyesight) to observe the undistorted version of the anamorphic image. In such circumstances, the anamorphic picture seen from the front is often so distorted that it is unidentifiable. In other words, the anamorphic illusion uses the rules of linear perspective to create a two-dimensional image so distorted that it looks correct only when viewed from a particular angle or with a mirror that counters the distortion. Linear perspective, as a principle, states that the size of an object's visual image is a function of its distance from the eye. As a result, as the distance between two things increases, they appear closer together, as seen in railroad tracks that seem to converge towards the vanishing point (the horizon). This monocular cue provides a sense of depth even when it does not exist. Therefore, anamorphosis is an example of how we rely on monocular cues such as linear perspective to see depth, even when depth is only imagined.

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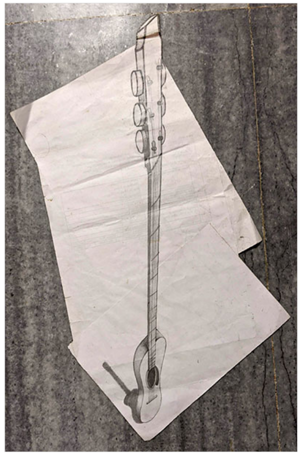

Figure 8.2.d
Source: Alen Antony Francis

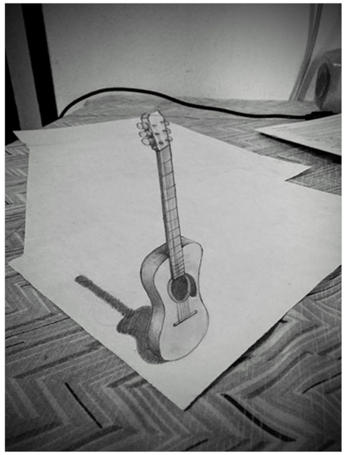

Figure 8.2.e
Source: Alen Antony Francis

Here is another example of anamorphosis; the guitar looks distorted in the left image. However, when viewed from the correct vantage point, it looks 3D. So, where can we use anamorphosis?

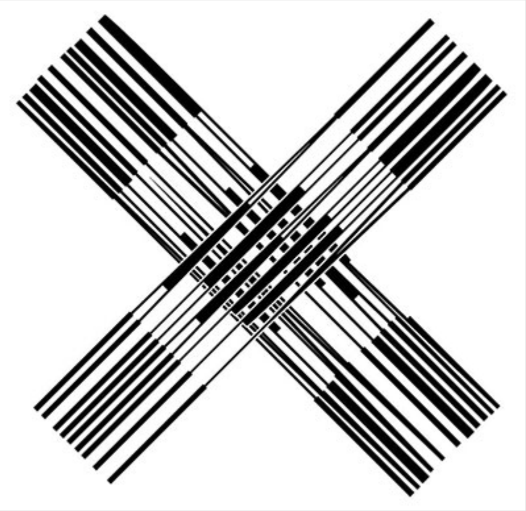

Figure 8.2.f
Source: Alen Antony Francis

What about this distorted image above? Can you guess what is written on the page? If you cannot, then please see the video below.

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by
Vivek Kant and Sruthi Sridhar
IDC, IIT Bombay

Source:
https://www.dsource.in/course/visual-perception-communication-designers/8-depth-and-perspective/82-anamorphosis

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Source: Alen Antony Francis

While the art field is the most typical application of anamorphosis, it is far from the only one. Whether you travel to work or the supermarket, you're likely to encounter an anamorphic illusion without realizing it. Road signs painted directly on the road are designed for the passengers in vehicles moving at greater speeds to see. These are achieved by stretching the letters or images to give them a more typical appearance while driving. Most people aren't aware of this optical illusion unless they stop and look attentively. Anamorphic illusions are finding their way into the advertising industry as well.

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8.3 Impossible Figure

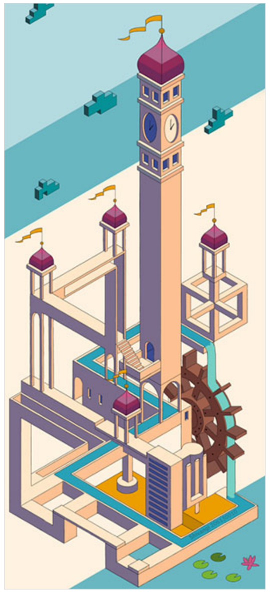

Figure 8.3.a
Source: Shivangi

We can see a picture of what you could interpret as a clock tower with a "waterfall." However, this picture is filled with shapes that cannot exist in the natural world. It is filled with impossible shapes. What is precisely an impossible object, and why does this look like a building that could have existed in the real world until we take a closer look? In these sets of illusions, issues of depth and size play an important role.

An impossible object is an object that cannot occur according to established physical laws but has a characterization or depiction that makes it appear plausible at first glance. It consists of a two-dimensional figure that the visual system quickly and subconsciously interprets as a projection of a three-dimensional object. After a few seconds of examining the figure, the impossibility becomes obvious. However, the initial impression of a 3D item persists even after it is refuted.

Impossible objects come under the branch of cognitive illusions. Unlike those with a physical or physiological foundation, cognitive illusions emerge when stored knowledge and assumptions are misdirected. The illusion is perceptual, yet it is within conscious control to some extent (It is possible to reverse cognitive illusions at one's will).

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Ambiguous illusions and paradox illusions are types of cognitive illusions. Ambiguous illusions occur when visual information cannot confirm a single view, causing an image or object to shift in appearance. The switch is perceptual, implying that the mind is involved in the interpretation. The Necker cube (simple wired symmetrical cube) is a famous example. In this Necker cube, the cube face in the front shifts to the back when more attention is paid to the backface.

In contrast, paradox illusions feature items that would be hard to build as continuous objects, such as the Penrose triangle or the impossible staircases depicted in M. C. Escher's work. The illusion of the impossible triangle is based on a cognitive mistake that adjoining edges must join. Perceptual learning produces such illusions as a side effect. Perceptual learning is the improvement of our ability to make sense of what we see, hear, feel, taste, or smell because of our experiences. It is a bottom-up process that is permanent or semi-permanent, where we use our previous experience to make sense of the world around us.

We will be looking at six different types of impossible figures and examining how each of them is perceived by our brains. The six impossible figures would be Penrose Triangle and stairs, Neckner's cube, Impossible cube, Devil's fork, and Escher's waterfalls.

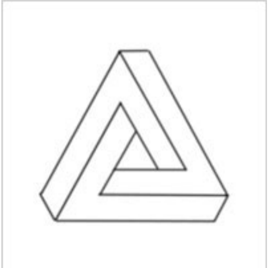

Figure 8.3.b
Source: Shivangi

We will first examine Penrose Triangle (also known as Tribar or impossible triangle), Penrose stairs and Escher's waterfalls. The Penrose triangle and stairs were designed by Oscar Reutersvärd from Sweden, popularised by Roger Penrose, and eventually featured extensively in the works of M. C. Escher.

The Penrose triangle seems to be a two-dimensional representation of a three-dimensional triangle made of square beams. However, any 3D object cannot achieve the properties of this 2D depiction. The Impossible Triangle cannot exist
because the principles of Euclidean geometry would have to be broken for it to exist. For example, the bottom bar of the tribar is spatially present in front of and behind the uppermost point of the tribar.

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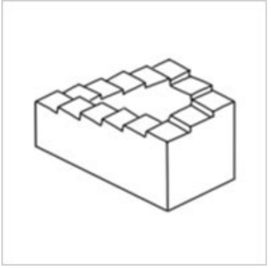

Figure 8.3.c
Source: Shivangi

The Penrose Stairs is a two-dimensional staircase with four 90-degree turns forming a continuous loop. The stairwell could potentially be climbed or descended endlessly without ever reaching its destination. Perspective distortion is the source of this illusion.

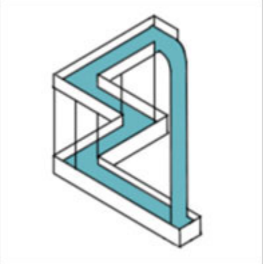

Figure 8.3.d
Source: Shivangi

The Escher waterfall is made up of two Penrose triangles. The water at the waterfall’s base appears to flow downhill, and if one follows the water’s path until it reaches the end, it seems to be at the peak of the waterfall. These illusions rely on the perception of two-dimensional images as three-dimensional objects by the human eye. The illusion of a three-dimensional object that cannot possibly exist is created by distorting visual perspective. A problem develops because perceptual learning instructs us that adjoining edges must be connected. Moreover, we also believe that features that seem touching in 2D must be at the same distance from us as viewers. The illusion is further enhanced using perspective to generate depth

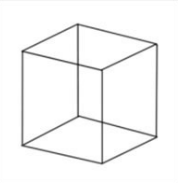

Figure 8.3.e
Source: Shivangi

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The next object we will focus on will be Necker's cube and the impossible cube. The Necker cube was invented in 1832 by Louis Albert Necker, who noticed that ambiguous cubic structures could change perspectives spontaneously. The Necker cube is a wire-frame cube with an ambiguous line design. There are no clues to detect whether one-line overlaps in front of or behind another when drawing in an isometric perspective (visually representing 3D objects as 2D). This produces an ambiguous situation in which the 3D cube can be oriented in two different ways. When viewing a representation of the Necker cube, it frequently appears to switch between the two possible interpretations (like the figures below)

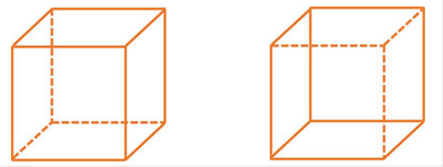

Figure 8.3.f
Source: Sruthi Sridhar

Because the line drawing of the cube is ambiguous, the brain picks an interpretation of the unclear portions that make the entire figure consistent. It's rare to encounter an inconsistent cube interpretation (the impossible cube is an example of an inconsistent interpretation). The brain chooses between two alternative perceptions in the three-dimensional world. When looking at the Necker cube, most people consider the lower-left face to be in front. This could be because people look at things from above more often than underneath. When offered a choice, the brain selects the interpretation that closely resembles daily life. There's also evidence that the brain evaluates visual images based on previous experiences, which helps perceive depth in this illusion.

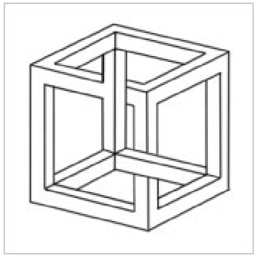

Figure 8.3.g
Source: Shivangi

The ambiguity in a Necker cube depiction is used to create the impossible cube. M. C. Escher is credited with inventing the impossible cube. A Necker cube with solid beam edges is commonly used to represent an impossible cube. Because of its apparent solidity, the impossible cube has more visual ambiguity than the Necker cube (which is less likely to be recognized as an impossible object).

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All the corners appear correct when looking at the impossible cube, yet the cube's edges overlap in unexpected ways. The trick, just like the Penrose triangle, relies on the human eye's ability to interpret two-dimensional images as three-dimensional objects. The sense of depth is created via visual perspective, even though the three edges on the back of the cube are in the front.

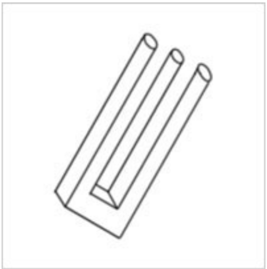

Figure 8.3.h
Source: Shivangi

Finally, we have the Devil's fork (also known as blivet or impossible fork). D.H. Schuster is believed to have created the prong in 1964. It looks to have three cylindrical prongs on one end that unexpectedly turn into two rectangular-shaped prongs on the other end. Often, the blivet appears plausible at first glance, but upon closer scrutiny, it becomes impossible to decipher. The prongs are formed by joining lines that extend from one side to the opposite end. The illusion gets more convincing the more extended the fork's prongs are and the further apart the two sides are.

A few fundamental questions arise when we look at shapes like these: Why do we keep seeing these figures as impossible objects even though we know they cannot exist? Why don't we consider the figures as 2D lines on a page? Or merely as representations of other 3D objects consistent with the lines on the page? For example, if we look at the impossible cube, it initially just looks like many 2D lines on a page. However, perceptual learning recognizes these as three-dimensional objects, such as a cube in this case. Part of the solution to these questions is that our visual system is independent of our belief system, at least to some extent. Visual illusion experiences, for example, persists even when one believes one is experiencing an illusion. Like the lighting checkerboard illusion you will encounter in this course, we could only see the tiles as being different colored even after acknowledging that they are the same-colored tiles. However, that is not the complete story. The question remains: why would the visual system not change the interpretation autonomously?

Many psychologists believe the answer is that the visual system functions by strictly following specific rules, even if doing so results in inconsistency. Psychologists try to figure out these rules by studying impossible objects (and other perceptual phenomena). They believe, for example, that the visual system obeys the law of proximity when viewing the impossible triangle.

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If there is no apparent gap between elements portrayed in an image, they are viewed as forming a whole and connected. Therefore, the figure in the first image is not regarded as an object with shape as it lacks conjoined ends. However, when viewed from an angle, it seems like there is no obvious space between the ends, and it is regarded as an object with shape. These impossible figures are also important for the designer. While making them, you will encounter a reflexive and deep understanding of the phenomena and how it affects the experience.

- Impossible Figure......

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https://www.dsource.in/course/visual-perception-communication-designers/8-depth-and-perspective/84-autostereogram

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8.4 Autostereogram

Follow the instructions below and then look at the picture. Focus on the eye icon and relax your eyes until you have double vision (the two icons will become four). Then pull back the vision so that the icons overlap, and you see three icons. Then focus on the brain icons, and you should be able to see the illusion.

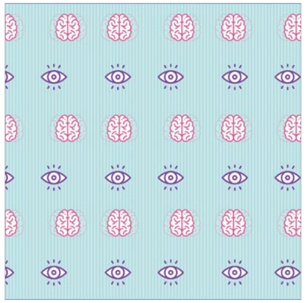

Figure 8.4.a
Source: *Aparna Khadtare*

Does the brain icon seem to be floating? Do the icons appear bigger? This is known as the autostereogram.

Autostereograms create 3D perception from horizontally repeating patterns by slightly altering the distance between the repeating objects. Our pupils are about 60mm apart, meaning each eye gets a slightly different picture projected onto its retina. This is known as binocular disparity (described above in section 8.1). We do not have constant double vision from these two pictures because the brain immediately combines them into one. And in doing so, it uses the difference in the two pictures to add depth to our visual perception and help in our depth perception or stereopsis (3D vision).

Charles Wheatstone first described stereopsis in 1838. Wheatstone revealed stereopsis with a device known as a stereoscope that could display a slightly different image to each eye, simulating how each eye would take in a real-life 3D object but with flat images. Following this invention, David Brewster, a Scottish physicist, invented a handheld stereoscope which became quite a popular household item during Victorian times. In the 1960s, Bela Julesz created a computer-generated random-dot stereogram. These images could be seen using a stereoscope or by focusing on a point beyond the picture by 1980.

Christopher Tyler and Maureen Clark developed an algorithm that could embed more detailed depth images into a random dot autostereogram. The algorithms that produce these images work from a depth map. A depth map is a black and white image that tells the program to make the repetition interval shorter for the dots that make up the lighter and nearer parts of the picture. One can view these types of autostereograms without a stereoscope.

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For example, if you view the stereogram below, it is created using a depth map, and you should be able to see a shark.

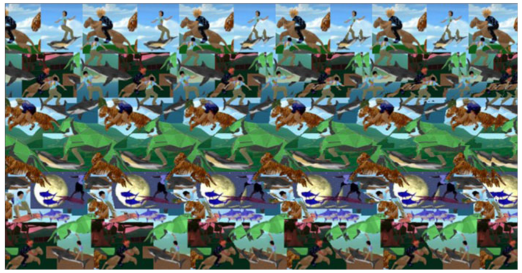
Figure 8.4.b
Source: Shreyas Vernekar

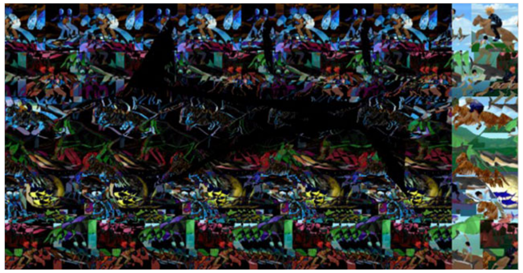
Figure 8.4.c
Source: Shreyas Vernekar

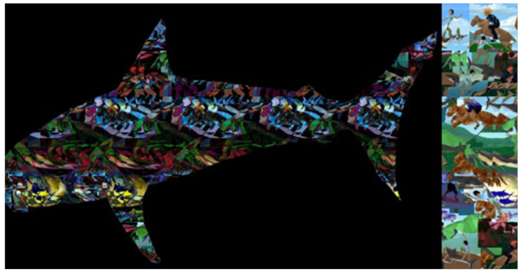
Figure 8.4.d
Source: Shreyas Vernekar

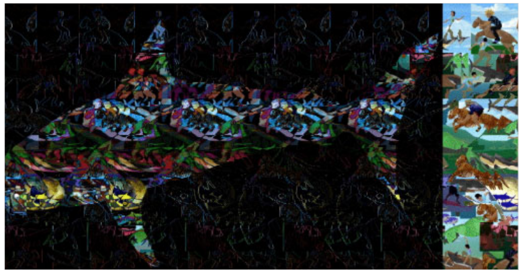
Figure 8.4.e
Source: Shreyas Verneka

A depth map in 3D computer graphics and computer vision is an image or image channel that provides data on the distance between the surfaces of scene objects from the point of view.

For example, here is how the depth map for a stereogram of a wolf would look like

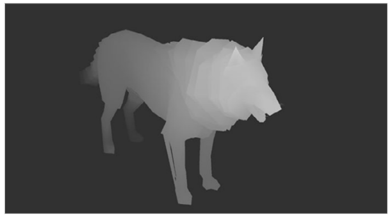
Figure 8.4.f
Source: Shreyas Vernekar
This is what the nearest light depth map would look like.

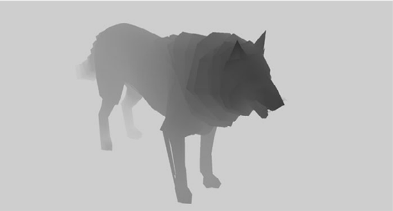
Figure 8.4.g
Source: Shreyas Vernekar

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This is what the nearest dark depth map would look like. So, in an autostereogram containing the wolf, the nearest parts would repeat at shorter intervals than the more distant parts of the wolf. Except for the parts that make up the wolf, everything on the base image replicates at the same interval.

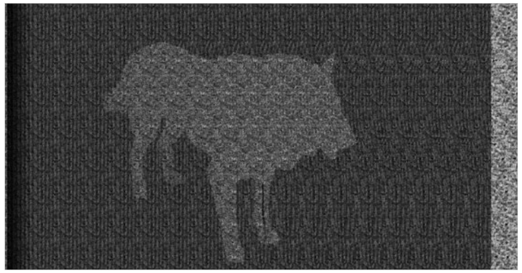

Figure 8.4.h
Source: Shreyas Vernekar

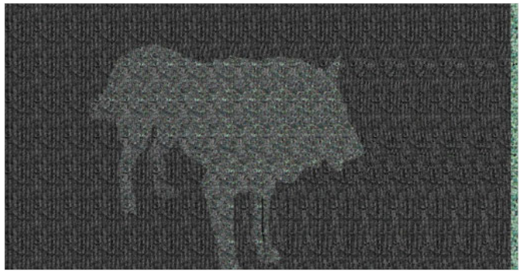

Figure 8.4.i
Source: Shreyas Vernekar

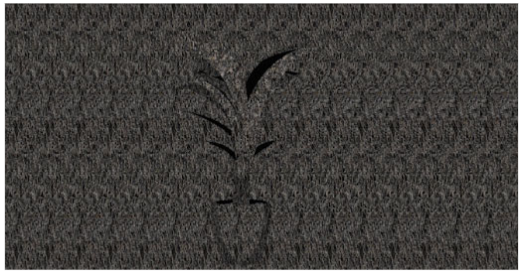

Figure 8.4.j
Source: Shreyas Vernekar

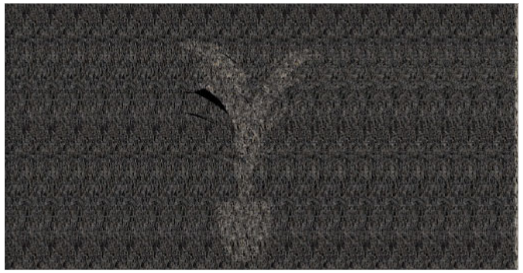

Figure 8.4.k
Source: Shreyas Vernekar

Figure 8.4.l
Source: Shreyas Vernekar

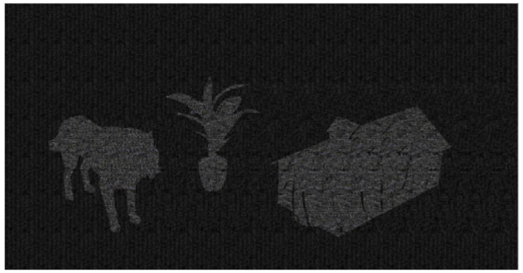

Figure 8.4.m
Source: Shreyas Vernekar

There are two methods to see a stereogram. The first one is the cross-eyed method (convergent viewing). In a cross-eyed stereogram, there is usually a reference point between the eyes and the stereogram that one must concentrate on to see.

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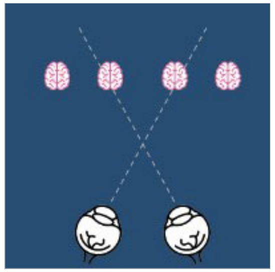

Figure 8.4.n
Source: Aparna Khadtare

The wall-eyed method (divergent viewing) is the second way to view stereograms. This is the method used for the autostereogram in the picture above. In the wall-eyed method, the viewer will have to relax their eyes as though they are looking through the screen, and they should see the pattern as if it is floating and separate from the background.

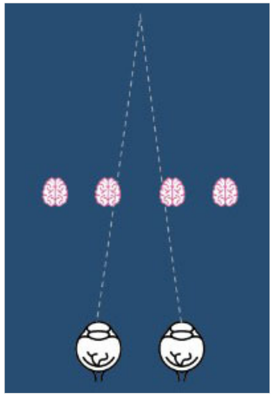

Figure 8.4.o
Source: Aparna Khadtare

Traditional stereograms will have what looks to be a random pattern but with hidden images in them. However, the image above exemplifies a "wallpaper stereogram." This type does not have a hidden image. Instead, it has repeating patterns that appear at different levels of depth when you diverge your eyes.

Traditional stereograms are designed to be viewed using the cross-eyed method, but the example above is for divergent viewing. This means that rather than having your eyes pointed at the image itself, you should over-diverge your eyes as if you are looking through the image at something beyond it. This is tricky because the lens in our eyes usually focuses on what our eyes are pointing at (object/image). However, for a divergent viewing stereogram, you need to try and focus on the image while pointing your eyes at a spot beyond it.

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How does this work?

This diagram shows the view from above your head, and these dots represent icons on a simple autostereogram.

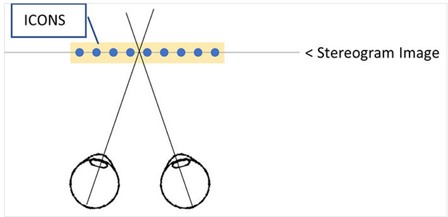

Figure 8.4.p
Source: Sruthi Sridhar

When you let your eyes diverge, instead of fixing them on one of these icons, each eye sees its own icon. Because your brain is used to turning two similar pictures into one – it assumes the two icons are actually one icon that's further back and larger, rather than two that are closer.

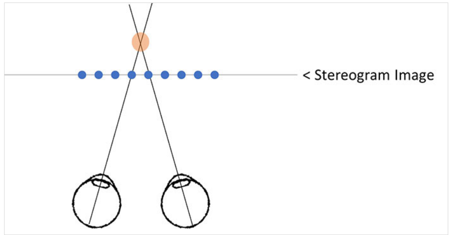

Figure 8.4.q
Source: Sruthi Sridhar

This illusion happens across the image, with every pair of repeated icons wrongly interpreted as one. The right-most and the left-most icons don't have pairs on their other side, so you end up with seven – five illusory icons plus two edge ones. If there are pairs that are repeated at closer intervals, they would appear nearer to you. So, the interval of repetition can be manipulated to adjust depth.

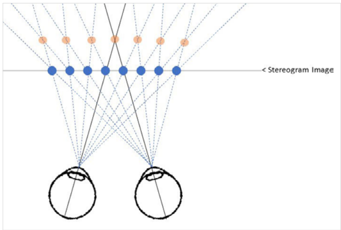

Figure 8.4.r
Source: Sruthi Sridhar

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Where can autostereograms be used?

Artists can use them to create exciting artwork. For example, Salvador Dali created impressive stereograms in his explorations of optical illusions. The military used a stereoscope in World War Two to create 3D aerial photography and identify Nazi camps. Stereoscopy is the most widely accepted method for capturing and delivering 3D videos with the help of a 3D camera. The Mars exploration rovers launched by NASA to explore the surface of Mars are equipped with unique cameras that allow researchers to view stereoscopic images on the surface of mars.

One can download a short depiction of the autostereogram here:

Source: Aparna Khadtare
- Autostereogram......

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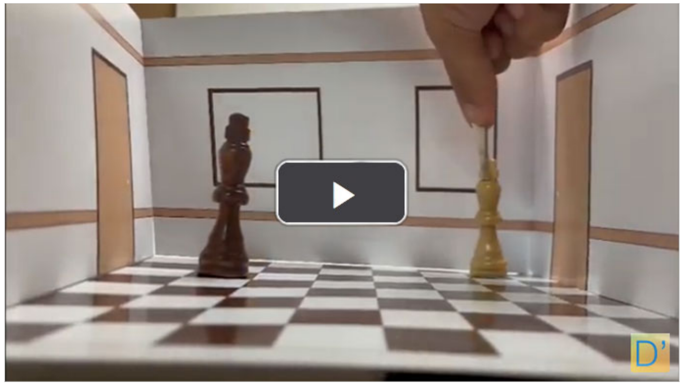
8.5 Ames Room Illusion

Take a look at the video below:



Source: Darshan Malviya

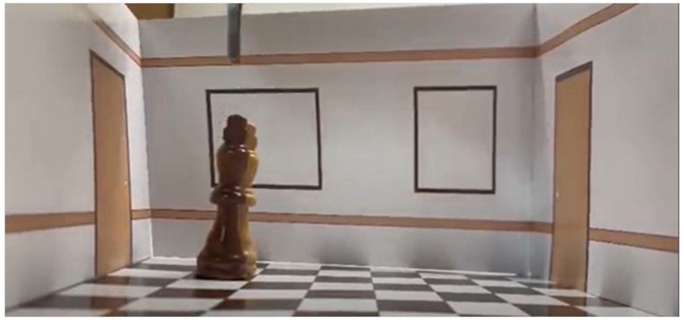


Figure 8.5.a
Source: Darshan Malviya

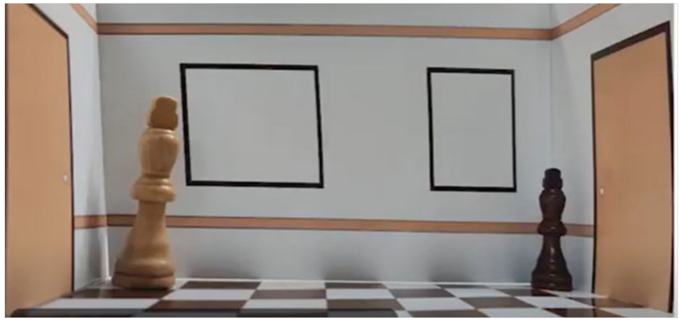


Figure 8.5.b
Source: Darshan Malviya

In the picture above, we can see an identical-sized black and white bishop. However, when these two pieces are placed on the opposite sides of the same room, would you say they are of the same size?

Doesn't the white bishop look bigger than the black one? How is this possible? How does something of identical size look so drastically different? This is the magic of the Ames room. An Ames room is a distorted space that provides the optical illusion of relative sizes. Regular perspective is lost when looking at people or objects in an Ames room. The picture below displays what actually happens in the room.

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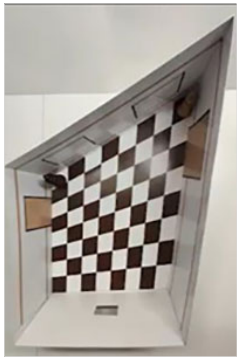

Figure 8.5.c
Source: Darshan Malviya

A chess piece standing in one corner appears to the viewer to be substantially larger than the piece located in the other corner due to the optical illusion produced by the warped environment. The room is actually trapezoidal; however, looking from a peephole, it looks like a rectangular room. The deception is strong enough to give the impression that a chess piece going back and forth from the left to the right corner is “growing” or “shrinking.”

The idea of the “Distorted Room” is not new. It has appeared in various entertainment toy rooms over the centuries. A Distorted Room was built in 1946 by ophthalmologist Adelbert Ames. Ames expanded on Helmholtz’s idea by creating the room and conducting experiments in it, learning that fundamental rules of physics could appear to be broken in a Distorted Room. Distorted rooms were built before also in the past in various forms for entertainment. In our current times, it is also used in movies such as the Lord of the Rings to show tall characters (Gandalf the Grey) and extremely short characters (hobbits).

Videos of demonstrations of Ames Room (1951):
- https://www.youtube.com/watch?v=W_5wpPxCcyw&t=1254s

Fun demonstrations of distorted rooms (2020):
- https://www.youtube.com/watch?v=uTCJuwZpimk

How exactly does the Ames room work?

An Ames room is designed with a rear wall, two parallel side walls, and a horizontally level floor and ceiling. From the front, the room looks to be an average rectangular room. This rectangular appearance is a perspective illusion. The room is trapezoidal because of the sloped walls, incline of the ceiling and floor, and proximity of the right corner to the observer in the front (or vice versa). To get the optimum perspective and eliminate any sense of depth, observers peer through a peephole into the room. Additional visual perspective cues, such as a checkered floor and “rectangular” windows on the wall, frequently augment the illusion.

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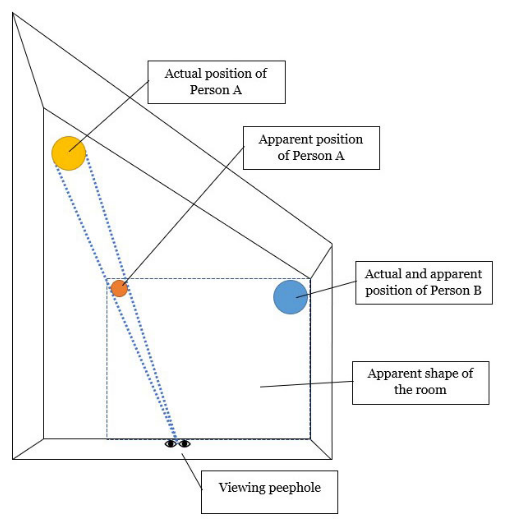
Actual position of Person A
Apparent position of Person A
Actual and apparent position of Person B
Apparent shape of the room
Viewing peephole

Figure 8.5.d: Structure of Ames Room from the top
Source: Sruthi Sridhar.

How would you construct an Ames room?

The steps below show how an Ames room is being constructed. Notice the perspectival texture on the floor and the sides of the wall. This ensures that the size illusion is maintained. More full demonstrations of Ames room construction are created by various contributors and are listed at the end of this section.

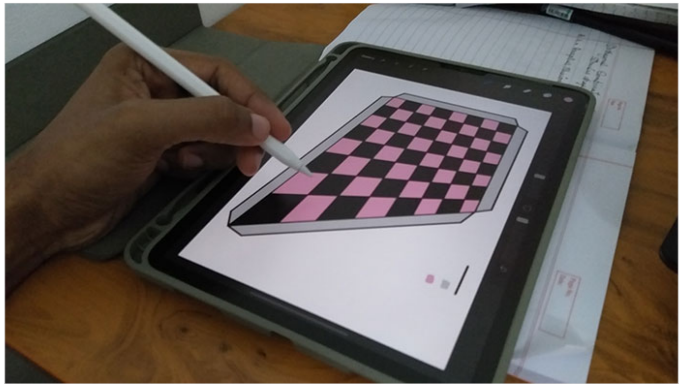

Figure 8.5.e
Source:Hirosh A C

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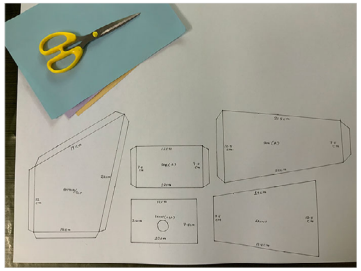

Figure 8.5.f
Source:Hirosh A C

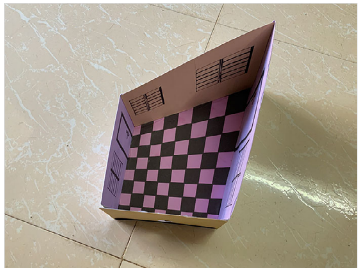

Figure 8.5.g
Source:Hirosh A C

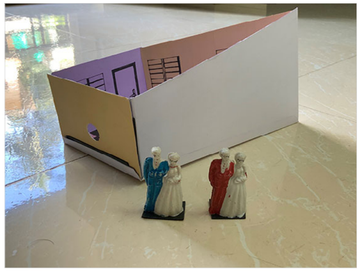

Figure 8.5.h
Source:Hirosh A C

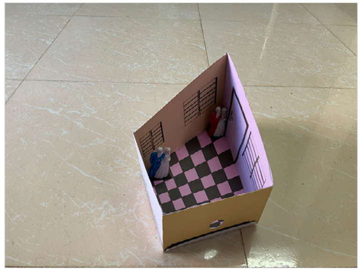

Figure 8.5.i
Source:Hirosh A C

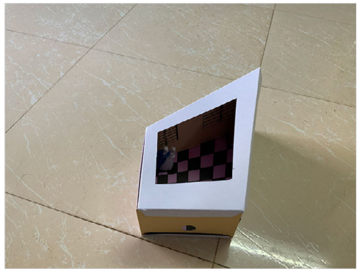

Figure 8.5.j
Source:Hirosh A C

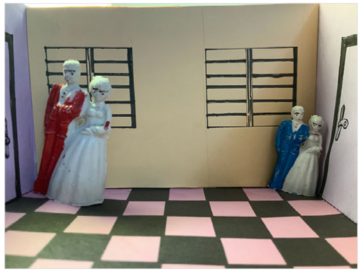

Figure 8.5.k
Source:Hirosh A C

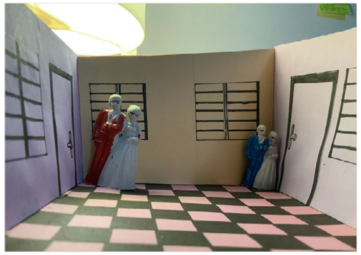

Figure 8.5.j
Source:Hirosh A C

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AOur perception of when the room is empty as a regular is unsurprising because the image we view via the peephole is the same as what we would expect in a typical rectangular room. However, there is disagreement when people stand in the room.

Please look at the video demonstration below.

Source: Divya Gaur

Here is an example of two identical figures being placed in an Ames room.

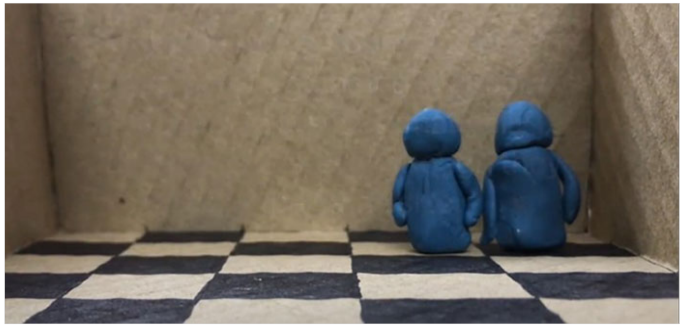

Figure 8.5.m
Source: Divya Gaur

Due to the distance from the observer, the person standing in the farther corner appears smaller than the person in the nearer corner. The observers perceive the distortion in the sizes of objects/people but cannot perceive the room as trapezoidal. The room is still perceived as rectangular, which may be expected because onlookers are probably used to seeing rectangular rooms, not trapezoidal ones. In addition, several depth cues are contrived to recreate the illusions, and the walls may be painted in a certain manner to mask the fact that the room is long on one side. Further, the texture on the floor can also be devised to mask that the room is longer on one side.

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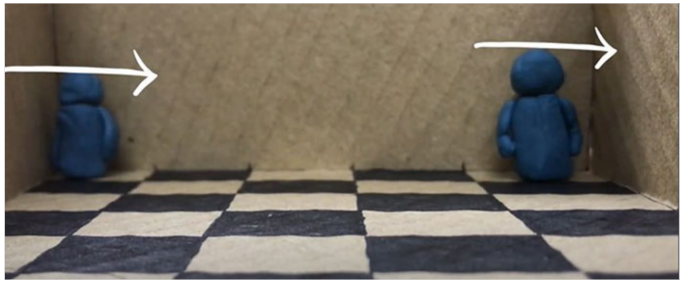
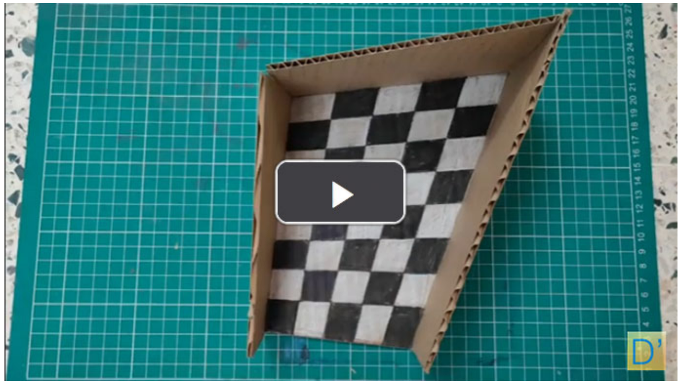


Figure 8.5.n
Source: Divya Gaur

A child in the closer corner will appear larger than an adult in the farther corner. Ames and other academics utilized this phenomenon to show how necessary experience is to perception. We tend to have the incorrect impression that the room is standard and that the occupants are all different sizes. Surprisingly, one can achieve the illusion of distorted size without an entire room; all that is needed is an apparent horizon against the right background. The eye then uses an object's perceived relative height above that horizon.

Several movies have used the Ames room, including Willy Wonka and the Chocolate Factory from 1971. To ensure that the hobbits' heights when standing close to Gandalf were accurate, The Lord of the Rings trilogy's production team used several Ames room sets in Shire scenes. In one episode of the 1960s television programme Voyage to the Bottom of the Sea, the producers used an Ames room to demonstrate a plot point in which two characters—one standing on either side of the room— went insane rather than simply declaring it.

Here are more creative demonstrations of the Ames room:



Source: Kashish Panjvani

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Source: Shraddha Prabhu

Source: Shreya Kondvilkar

Source: Aparna Khadtare

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9.1 Fundamentals of Attention and Change

How can communication designers understand the role of attention and change in visual design?

In everyday life, we often pay attention to multiple things at once, a phenomenon referred to as divided attention. For instance, a server serving to a table must use divided attention. They need to take down the order from table one and recall what the customer at table six wanted, all while carefully balancing the dishes of food they are holding. However, our capacity to divide our attention has its limitations. For example, watching a movie during a lecture is not the most productive.

While divided attention occasionally happens in our daily lives, selective attention is more important. Selective attention is the act of concentrating on some things while disregarding others. Why do we choose to pay attention to some things while ignoring others? The answer could be the fact that we focus on intriguing things. However, a more plausible explanation would be the evolutionary development of our visual system, which functions effectively when you selectively focus on specific items in your environment.

How can one achieve selective attention?

Eye movement is one method of selective attention—scanning a scene to direct the fovea at areas we want to examine more thoroughly. We can also pay attention to things that are not immediately in our field of view. For example, a basketball player can dribble down the court while paying attention to a player on the offside before throwing a dead-on pass without looking. We can also directly stare at something while not paying attention to it. You may have experienced this when reading a book: Despite moving your eyes around the page and "reading" the words, you suddenly realize that you have no idea what you just read.

What elements help focus our attention?

While studying a scene, there are places where the eyes pause to take in information about a scene/scenario, and these pauses are called fixations. Eye movements known as saccades are represented by the lines connecting the dots. About three fixations are made every second when a person is asked to observe a scene.

Where do we focus our attention on a scene? The answer to this question is complex because our looking behaviour depends on various elements, such as scene qualities and the observer's knowledge and objectives.

The term "stimulus salience" describes environmental features that stand out due to physical attributes like colour, brightness, contrast, or orientation. High stimulus salience regions stand out, such as a bold yellow "M" against a red background.

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But not everything that attracts attention is bright or conspicuous. It's also crucial to consider cognitive factors. It has been determined that a variety of cognitively based aspects are critical in assessing where a person looks.

Where we look can be influenced by our understanding of the things frequently seen in particular situations and the things often found together inside a scene. Imagine being in a cricket stadium; a cricket fan would be able to gaze and follow the game seamlessly. However, if you are someone who is not familiar with the game of cricket, you will have difficulty deciding where to look in a stadium at a particular point. This is true for multiple situations where your attention can be directed through each scene using your understanding of where things are typically found in these scenarios.

Another aspect important while addressing the phenomenon of attention is learning from past experiences. Suppose a person is adept at making tea. In that case, they could automatically direct their attention to what is essential at that particular point, such as whether they have to focus on the stove or on adding more ingredients.

A variety of things affect how someone examines a situation. At first, salient features might catch someone's eye, but cognitive variables take on greater significance when the observer's understanding of the scene's meaning starts to influence where they fixate. What a person is doing within a scenario is even more significant than the scene itself—both making tea or operating a vehicle influence where we look.

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9.2 Inattentional Blindness

How does a lack of selective attention influence our perception?

Please take a look at the YouTube video below. Follow the instructions:
- Selective Attention Test

Were you able to see the gorilla?

This phenomenon you just observed in the video is known as inattentional blindness - the failure to notice a stimulus that isn't attended, even in plain sight - provides evidence that attention is required for perception. This momentary unawareness is probably caused by the plethora of visual stimuli that demand attention.

There are a few requirements that an event or situation must meet to classify as an incident of inattentional blindness:
1. The observer should not recognize a visual event or item.
2. The entire optical stimulus must be visible.
3. It should be simple to identify if the observer consciously notices the signal.
4. The stimulus must be unexpected, and the inability to notice it is due to a breakdown in attention, not flaws in the visual picture or the optic stimulation.

Daniel Simons and Christopher Chabris conducted arguably the most well-known investigation on inattentional blindness, popularly referred to as the "Invisible Gorilla Test" (video). Many spectators were preoccupied with the difficult task of tracking throws and passes; thus, despite the gorilla's evident prominence, they had missed it. In the experiment, the participants completely blocked out other visual information because they were preoccupied with counting how many times the white team passed the ball. Therefore, they missed detecting the gorilla. About 46% of the participants failed to notice the gorilla during their first trial.

Source:
https://www.dsource.in/course/visual-perception-communication-designers/9-perception-attention-and-change/93-change

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9.3 Change Blindness

Pay close attention to all aspects of the video.

Source: Lakshmi Chandran + Midhun Mohan + Nidhin Joseph

Did you notice if there was anything that changed in the video? At least five things changed in the video: the colour of the lighter, the order of the book arrangement, the placement of the chess pieces, the cup on the side, and finally, the colour of the placemat itself. However, one could not have noticed all of these changes. This is known as change blindness.

Here is the video displaying all these changes.

Source: Lakshmi Chandran + Midhun Mohan + Nidhin Joseph

Failures of visual awareness are prominent in both change blindness and inattentional blindness. The failure to recognize a clear shift is known as change blindness, whereas the failure to recognize the presence of an unexpected item is known as inattentional blindness. We miss out on something readily apparent in each instance as we do not know where to search for it.

Change blindness is the inability to recognize changes in a scene. It is more common than we imagine. This inability to recognize a change in movies is a typical occurrence. Popular movies frequently feature scenes where a crucial element that ought to stay the same shifts from one shot to the next, much like things in real life. These modifications in movies, known as continuity errors, are picked up by viewers seeking them, typically by seeing the movie more than once. However, spectators in cinemas who are not looking for these faults usually miss them.

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9.4 Why does inattentional blindness and change blindness take place?

One apparent reason is the mental workload. According to the mental workload theory, when we devote a lot of mental energy to one stimulus, we exhaust our cognitive resources and are unable to comprehend additional stimuli at the same time. Similarly, some psychologists describe how we pay attention to various stimuli with differing degrees of attentional capacity, which may impact our capacity to process several stimuli simultaneously. For instance, when someone concentrates intensely on one stimulus (such as a text on a phone while driving), they pay less attention to other stimuli (e.g., the position of other cars on the road).

Another reason is known as conspicuity. According to the principle of conspicuity, sensory and cognitive stimuli are two categories that are more likely to be processed. Sensory stimuli could be colour, brightness, and cognitive stimuli could be something familiar. As a result, stimuli that do not fall into one of these two groups may be overlooked. Seeing a gorilla in a basketball game is unusual in the actual world and is one of the reasons why people so frequently "miss the gorilla." Also, due to the busy focus on white T-shirts, the brain "zones out" the people in the black T-shirts. As a result, the brain misses the black-coloured gorilla, which is completely focused on tracking white T-shirts passing the balls. Consequently, one could not notice such peculiar visual cues while preoccupied with cognitively taxing tasks such as observing the game's specifics.

While a visual stimulus's salience is determined by its physical characteristics, its cognitive salience is determined by the observer's previous knowledge. Inattentional blindness will likely result when a stimuli's sensory or cognitive conspicuity significantly decreases. For instance, an object that is visible but not visually striking may pass unnoticed. On the other hand, if an object is unrelated to the observer's interests, even a visually intriguing object may fail to hold the observer's attention.

As mentioned previously, change blindness is when an observer fails to detect a change made to the visual stimulus. The interstimulus interval is the brief period between the two subsequent visual scenes, with the latter slightly modified.

The visual sensory memory register, known as iconic memory, is where visual images are stored after a physical stimulus has ceased to exist. Although it has a large capacity, iconic memory deteriorates quickly. Typically, information recorded in iconic memory vanishes in less than a second.

The iconic memory store is hypothesized to be diminished by the interstimulus interval duration. In other words, recognizing changes in a visual scene depends on iconic memory. But when the interstimulus gap gets longer, the likelihood of failures in iconic memory increases, causing change blindness.

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Here is another example of inattentional blindness

Source: Madhuri Suresh, Jinal Shah & Reshma Issac

Here are a few more examples of change blindness videos and what has been changed.

Main Video: https://www.youtube.com/watch?v=qnczjwSXz7I
Source: Susana Gomez

Main Video:
Source: Vedang Pathre

The Deo Bottle changes more than once throughout the video

Explanation Video:
Source: Vedang Pathre

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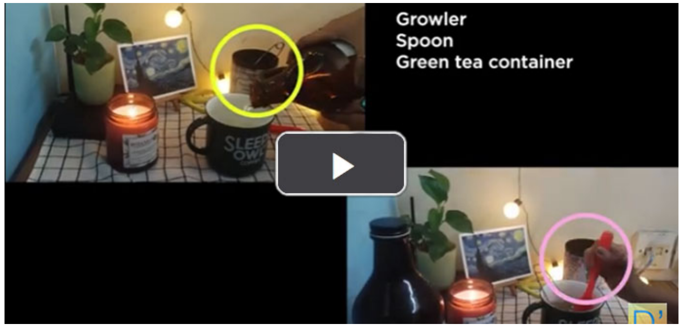
Main Video:
Source: Dishant Mehlawat, Hemant & Yash Vardhan

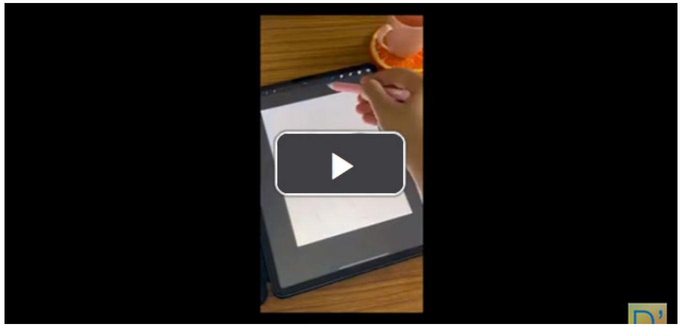
Explanation Video:
Source: Dishant Mehlawat, Hemant & Yash Vardhan

Source: Kunal Khawaskar

Main Video:
Source: Shreyas Vernekar, Sanskruti Landage & Akshata Khare



Explanation Video:
Source: Shreyas Vernekar, Sanskruti Landage & Akshata Khare



Source: Stuti Swamiwal

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Source:
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This course has provided an understanding of different types of visual phenomena and illusions and how communication designers can explore to understand their work better and incorporate them into their design. Both perception and design are active processes that go beyond simple conceptual knowledge. As you become more conscious of your reactions, they start to stand out and become easier to recognize as an active component of the awareness you bring to the experiences and objects in your surroundings and, more specifically, to your work as a communication designer. This might help inspire someone to look at design differently.

In this course, we looked at figure-ground segregation and different types of figure-ground illusions. Designing for any medium, such as artwork, photography, textiles, and crafts can incorporate alternating figure-ground interactions. When creating designs using words or letters, such as monograms, logos, posters, or holiday cards, a good technique is to use the negative spaces or the ground in letters as positive spaces or the figure. The figure-ground relation encourages you to explore each space in a lock-and-key pattern, which aids in organizing a cohesive and coherent design.

Next, we explored the illusions that use our perception of edges, lines, and angles. These illusions have varied uses in graphic design, where one can use them to produce fascinating visual effects. Designers and Artists regularly use illusions to enhance their work. Further, we explored how one can use the perception of color, brightness, and lightness in visual design. Explorations in this area are practically limitless as they can lead to varied possibilities for a particular design. We looked at several illusions using the perception of motion and illusory motion. One can use these to create different types of movies, advertisements, flip books, architecture, and other artworks.

We then looked at size distance illusions and depth perception illusions. Advertising professionals and surrealist artists frequently employ unrealistic size relationships. By playing with size connections, you sharpen your awareness of contextual cues. One can use depth cues to make abstract landscapes and gradients, creating robust 3D illusions. Graphic designers and photographers use these size-distance scaling principles all the time.

Finally, we looked at the role perception attention and change plays in visual design. Change blindness and inattentional blindness can have real-life implications in moviemaking. Filmmakers utilize these principles to ensure issues of continuity and meaning-making from an attentional and perceptual basis.

This course has been created with the expectation that visual designers in India will explore more of these phenomena in the future. This will help them to gain from advances in cognitive psychology and make them more reflexive about their work. It is hoped that communication designers will actively use these principles and incorporate them in their design work.

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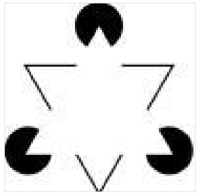
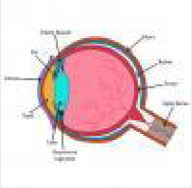


11.2 Appendix B: Gestalt thought and its precursors



11.3 Appendix C: Eye and the Light

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11.1 Appendix A: Eye and the Brain

Structure of the eye

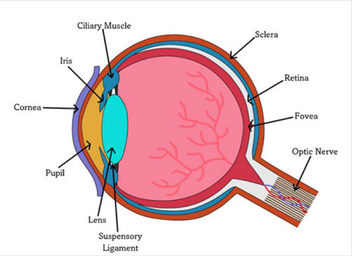

Figure 11.1.a
Source: Sruthi Sridhar

Light can enter the eyes either directly from a source (sun, light bulb) or indirectly through the reflection of an object (also reflected multiple times from various objects). In order to have a clear vision, a single point of light must travel through the structures present in the eye and land on the retina. In this process, refraction occurs as light bends when it passes through varying densities of matter. For example, a drinking straw appears broken on the water's surface. The structures in the eye are critical for gathering and focusing light so that humans can see clearly.

See detailed images of the eye:
- https://www.aao.org/eye-health/anatomy/parts-of-eye

The cornea is a transparent membrane that covers the eye's surface. The cornea shields the eye and focuses most of the light entering the eye. The cornea has a fixed curvature equivalent to if a camera lacked the ability to adjust focus.

The aqueous humour, a clear, watery fluid, is the next visible layer. This fluid is replenished regularly and provides nutrients to the eye. The light from the visual image then enters the eye's interior through a hole called the pupil, which is located in the iris. Iris is a circular muscle which is the colored part of the eye. The iris can adjust the size of the pupil, allowing more or less light into the eye, which helps focus the image. People try to achieve the same thing by squinting.

Muscles behind the iris suspend a clear structure called the lens. The cornea begins the focusing process, which is completed by the flexible lens. The lens changes its form from thick to thin during visual accommodation, allowing it to concentrate on close or far away things. The lens' thickness variation helps it to project a sharp image onto the retina.

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After passing through the lens, light travels through a large, open region called the vitreous humour, which is filled with a clear, jelly-like fluid. This liquid, like the aqueous humour, nourishes and shapes the eye.

The retina, a light-sensitive area at the back of the eye, has three layers: ganglion cells, bipolar cells, and rods and cones, which are unique receptor cells. These photoreceptors respond to various wavelengths of light. The retina is the final stop for the light within the eye.

While the retina absorbs and processes light, the rods and cones are responsible for receiving photons of light and converting them into neural activity for the brain. The signal is then transferred to the bipolar cell (a form of interneuron) and then to the retinal ganglion cells, whose axons form the optic nerve.

Different aspects of vision are controlled by the rods and cones. Each eye has 6 million cones, with 50,000 of them having a private line to the optic nerve (one bipolar cell for each cone). This means that the cones are the visual acuity receptors, or they have the capacity to discern fine details.

Rods (approximately 100 million in each eye) are located across the retina except in the fovea, where they are concentrated. Rods are sensitive to brightness changes but not to a wide range of wavelengths. Thus, they can only see in black and white and shades of grey. As multiple rods are linked to a single bipolar cell, the brain interprets a photon of light to stimulate an entire area of rods. The visual acuity (sharpness) is low because the brain does not know which region (which particular rod) is transmitting the message. As a result, things appear fuzzy and greyish in low-light situations like twilight or dimly lit rooms. Rods are also responsible for peripheral vision because they are located on the retina's periphery.

Cones can be found throughout the retina, although they are more abundant in the centre, where there are no rods (the area called the fovea). Cones also require a lot more light than rods to function; thus, they perform best in bright light, which is also when people see objects the best. Cones are responsible for color vision because they are sensitive to different wavelengths of light. While the eye supports many visual processing activities, such as the perception of lightness and brightness, due to lack of space, here we will deal with one such phenomenon of vision–the perception of color.

Perception of Color

In the 1800s, two hypotheses were proposed concerning how people perceive colors. The trichromatic ("three colors") theory is the first. This concept advocated three sorts of cones: red cones, blue cones, and green cones, one for each of the three primary colors of light. The theory was first proposed by Thomas Young in 1802 and later refined by Hermann von Helmholtz in 1852. According to the trichromatic hypothesis, color shades correspond to various amounts of light received by each of the three types of cones. The message from these cones is subsequently sent to the brain's vision centres.

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The visible color is determined by the combination of cones and the rate at which they are fired. For example, if the red and green cones fire at high enough rates in response to a stimulus, the person perceives yellow.

The trichromatic hypothesis appears to be more than enough to explain how people perceive color. However, this theory cannot account for an intriguing phenomenon. Let us experiment and focus on the union jack for at least a minute. Right after a minute, look at the white box next to it. What do you see?

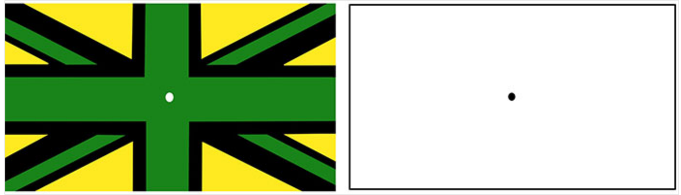

Figure 11.1.b
Source: Sruthi Sridhar. Recreated from Ciccarelli and White, 2018 (page 144)

You should have seen an afterimage of the flag. An afterimage is a visual sensation that lasts for a short period after removing the original stimulus. Furthermore, the person would notice that the flag's colors are all wrong in the afterimage: green for red, black for white, and yellow for blue.

The second theory, known as the opponent-process theory, which Ewald Hering proposed in 1874, explains the afterimages phenomenon. The opponent-process theory has four fundamental colours: red, green, blue, and yellow. Each hue is arranged in pairs, with each pair member acting as an opponent. The color red is coupled with the color green, and the color blue is paired with the color yellow. When one pair is overly stimulated, the other is inhibited and unable to function; therefore, there are no reddish-greens or blueish yellows.

So, how might such a pairing result in color after images? Some neurons are excited by light from one part of the visual spectrum and inhibited by light from another part of the spectrum. Let us imagine we have a red-green ganglion cell in the retina. The cell will have a very low baseline activity when exposed to white light. However, if there were a red light, there would be increased cell activity, and we would perceive the color red. If the cell is stimulated by a red light for an extended period, it becomes exhausted. When the red light is replaced with white light, the exhausted cell responds even less than before. Therefore, we see the color green, which is related to this reduced cell response.

The Visual Pathway

Along with the visual processing occurring in the eye, the visual system consists of the optical pathway and connects the eye to the brain.

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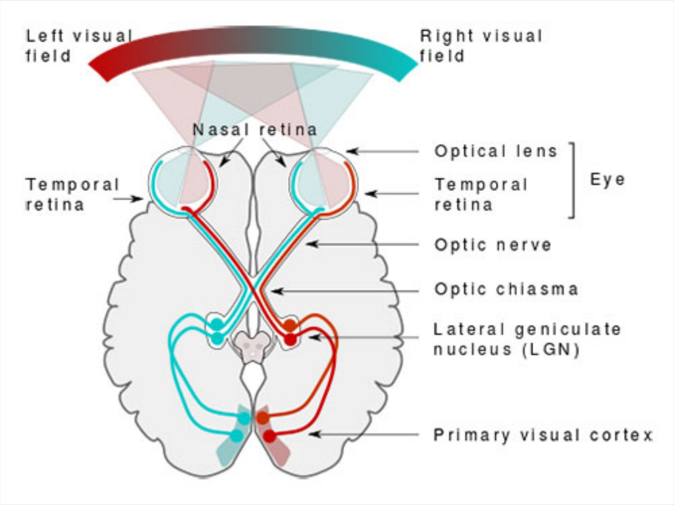

Source: *Wikimedia*

The retina is connected to parts of the brain called the primary visual cortex (see details in the picture). The left and right visual fields can be distinguished when light enters the eye. The left half of each eye's retina receives light from the right visual field. The right half of each retina receives light from the left visual field. Because light passes through the cornea and lens in a straight line, the image projected on the retina is actually upside down and inverted from left to right compared to the visual fields. The right visual cortex receives information from the left visual field and vice versa. The point of crossover is the optic chiasm.

The process of vision involves much beyond the concepts listed here. The above are just a sampling of some workings of the visual system, which have been explored in greater detail in this course. However, vision science remains a major area of research and can serve communication designers' detailed and reflexive understanding of the visual process.

Source:
https://www.dsource.in/course/visual-perception-communication-designers/11-appendix/112-appendix-b-gestalt-thought-and-its

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11.2 Appendix B: Gestalt thought and its precursors

The history of modern-day psychology dates back to the early 19th century. By the 19th century, 31 pairs of spinal nerves had been discovered, which connected the brain with different organs. Moreover, 12 known pairs of cranial nerves connected the brain to sensory organs. Until then, philosophers had actively discussed the mind, which remained the basis of psychology as a discipline. Psychology outgrew physiology and philosophy, emphasizing the scientific approach towards understanding the mind. Here we have listed a few notable researchers who have shaped the field of perception as we know it today. This is far from an exhaustive list, and we highly encourage you to understand the background history of perception for a detailed understanding of the major themes and trends in perception.

One of the foremost physiologists and physicists of that time was Hermann von Helmholtz (1821 – 1894). He studied the speed of nerve impulses by stimulating a motor nerve in a frog's leg. Helmholtz also studied the physiology of vision and audition. He invented the ophthalmoscope to examine the retina and study the physiology of vision.

Helmholtz is widely known in physiology as he proposed the trichromatic theory of vision that suggested the mixing and matching of three different primary colours: red, blue, and green, to produce colour vision. If you flash a red spotlight on a wall and then flash a green light such that it overlaps the red, the colours will "mix" and appear yellow (new colour). Helmholtz concluded that the eyes must have three different colour receptors (one for each colour). Incoming light of a specific wavelength was thought to excite these receptors to varying degrees, resulting in the impression of a particular colour.

Helmholtz also answered the question about how light becomes focused on the retina by proposing the concept of accommodation. Accommodation is when there is a change in the thickness of the lens as the eye focuses on objects that are either close or far away. He also examined the perception of depth and came up with the operation of binocular vision.

Helmholtz believed that the raw information processed by the sensory system itself is useless. Only when a specific set of sensory experiences is linked to particular outcomes does it become meaningful; he called this process unconscious inference. For example, in the case of a person approaching us, the retinal image of the person enlarges as they approach us, yet we interpret the individual as becoming closer rather than doubling or tripling in size. Therefore, he argued that we unconsciously infer that the person is getting closer as we know from experience that people do not actually expand or enlarge in size as they move towards us.

Wilhelm Wundt (1832 – 1920) was a student of Helmholtz and is often referred to as the father of psychology. He addressed nonphysical structures such as thoughts, experiences and emotions of the human mind, as well as the broader notions of how the mind is shaped by culture.

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Edward Titchener (1867 – 1927) was Wundt's student who expanded on Wundt's original idea in the USA and believed that one could break down every experience into individual emotions and sensations. He termed it structuralism as it focused on studying the structure of the mind. He applied introspective methods to studying thoughts as well as physical sensations. Introspection is a process of examining and measuring one's own thoughts and mental activities. By using this method, Titchener wanted to understand how one can address the elements of the mind.

In contrast to the prevailing view of structuralism in the early days of psychology, many psychologists were trying to comprehend a different yet comprehensive foundation for the mind. Unlike Wundt and Titchener, William James (1842 – 1910) was interested in studying consciousness. James focused on how the mind allowed people to function in the real world. He objected to the structuralist point of view and came up with functionalism which was the study of how the mind allows people to adapt, live, work and play.

In addition to William James, the gestalt theorists in Germany were also trying to comprehend human experience differently yet holistically. One can roughly place the origin of gestalt around 1910 to 1912 when the German psychologist Max Wertheimer did his apparent motion experiment. However, one can trace Gestaltist influence back to German philosopher Immanuel Kant. Kant highlighted the role of past knowledge and cognitive categories in shaping our present experience. By the late nineteenth century, the philosopher Edmund Husserl's phenomenology had emphasized the significance of direct descriptions of human experiences over introspection. He believed descriptions found via introspection were artificial and could not adequately describe the nature of these experiences.

Wertheimer believed that we could not understand mental activities such as perceiving and sensing by breaking them down into smaller pieces. He believed people were predisposed to seek patterns in the sensory information available to them. He became fascinated with apparent motion, in which a stationary object appears to move under certain circumstances. For example, five light bulbs flashing with a 60 msec interval between them would look like one continuous light moving down the series. There would be five separate sensory events (five bulbs flashing), but the perception would be a single continuous event (one light moving). He argued that we perceive the whole, meaningful figures rather than the components that come together to make the whole. He termed this the Phi Phenomenon to avoid the connotation of an "apparent" motion, as the motion was illusory. This approach was, thus, an assault on previous thought processes such as structuralism which focused on breaking down processes.

Apart from the various concepts in perception, such as figure-ground segregation and the principles of perceptual organization, Gestalt theorists are widely known for issues of meaning and value in science that the then-existing scientists had left out as outside the purview of scientific enquiry. However, this did not mean that they were not aware of the changes in natural science. Instead, they emphasized searching for science for human life and experience beyond mechanistic psychology.

Source:
https://www.dsource.in/course/visual-perception-communication-designers/11-appendix/112-appendix-b-gestalt-thought-and-its

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For example, they also extensively stressed thinking and problem-solving in a holistic sense. In order to demonstrate, these small vignettes are presented about two famous gestalt theorists – Wolfgang Kohler and Max Wertheimer.

Wolfgang Kohler did not entirely agree with how the then prevailing psychologists conceived thinking in a step-by-step, mechanical approach to problem-solving. Instead, consistent with his gestalt orientation, he maintained that problems are solved when people can see the whole problem and rearrange the problem's components into a new and meaningful configuration. Kohler believed that once the individual had reconfigured the pieces, the solutions had a perceptual feel, which occurred swiftly. He labelled this process "insight." He placed a chimpanzee named Sultan in a cage to study this process. Kohler put a banana outside his cave, and his task was to retrieve the banana. Kohler provided him with two hallowed bamboo sticks with slightly different diameters. Sultan quickly recovered the banana using a stick when placed just out of his reach. Then the problem was made more difficult as the experimenter placed the banana just out of reach of Sultan's extended arm with the stick in his hand. After about an hour of trying to get the banana, Sultan had a sudden 'aha' moment or a sudden flash of insight. He joined the two sticks and retrieved the banana. Kohler concluded that solutions occurred quickly and after the reconfiguration of all the elements in a novel way with insight. Köhler's study provided a new way of thinking about our approach to learning and problem solving, and it went beyond using simple puzzle boxes and mazes to study animals.

Similar to Kohler, In his book Productive Thinking (1945), Max Wertheimer applied gestalt concepts to education. He distinguished productive thinking from rote learning, which he described as lacking in comprehension, inflexible, readily forgotten, and only applicable in restricted settings. When a student must employ problem-solving abilities, he uses gestalt (wholistic) principles to learn. As a result, learning is adaptable, long-lasting, and applicable to various contexts (transfer of training). Students should rearrange the problem in various ways to develop productive thinking until a solution arises based on understanding. Using productive thinking, when students are taught how to find the rectangle's area using the concept of grids, they will apply unit area and find areas of non-standardized figures such as a parallelogram.

The wholism of the gestalt theorists was not without precedence. By the early 20th century, the idea of force fields was effectively entrenched in physicists' thoughts. For example, Max Planck emphasized how the total force field determined the nature of the relationships between the components of the field. For example, a magnetic field represents the force that creates an overall pattern of interrelationships between elements that cannot be understood by analyzing each element in the overall magnetic field. In this respect, the physicist Ernst Mach's description of certain "space-forms," which resisted analysis into basic elements, holds prominence. The idea can be explained as follows: for example, a square is made up of four perpendicular lines. These lines may change in shape, but the relationship among those four lines must stay the same for us to interpret it as a square. Therefore, the overall relationship is what counts when identifying the square, not the individual components. This is one of the key ideas in the gestalt school of thought, which recognizes the irreducibility of fields into their elements.

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Christian Von Ehrenfels agreed with Mach and spoke about entities/objects having form quality which is the overall quality of some entity which exists over and above its individual components. For example, a song played in different keys or using different instruments will have notes that change depending on the key, but the song’s melody itself does not change. In addition, we don’t just hear individual notes but the whole melody.

Franz Brentano, a notable philosopher, highlighted that it was essential to understand how the mind operates to create experiences. Therefore, he argued that rather than focusing on how we sense an object (which is what Titchener concentrated on), he believed that we needed to understand how an individual perceives an event and what personal significance the event hold.

He developed the idea of act psychology which was the study of mental acts and not mental contents, with the perception of some event. For example, one should not analyze an event into its elements but examine the act of perception (i.e., how the individual perceives the event and what the event means to the individual).

Brentano’s student Carl Stumpf was a talented musician and is credited for his work with auditory perception. In addition, he is also recognized widely for his work on phenomenology and philosophy. He was also the founder of the Berlin Institute of Psychology which gave rise to the Gestalt school of Psychology by Wolfgang Kohler, Kurt Koffka, Max Wertheimer, and others. The history of the gestalt school is much more nuanced, and its legacy continues beyond psychology into the discipline of communication design.

Design Course

Visual Perception for Communication Designers

Human Factors and Sociotechnical Systems Studios
by
Vivek Kant and Sruthi Sridhar
IDC, IIT Bombay

Source:
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11.3 Appendix C: Eye and the Light

In this section, we very briefly list out the basic definitions of light and its relation to vision. This appendix is meant to be a quick reference rather than an exhaustive resource.

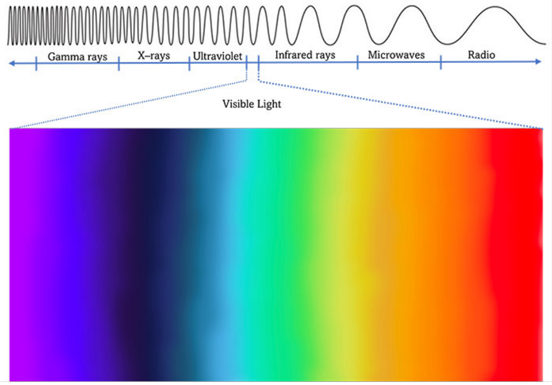

Figure 11.3.a
Source: Sruthi Sridhar. Recreated from Goldstein, 2010 (page 44)

Visible light, a band of energy within the electromagnetic spectrum, helps form vision. The electromagnetic spectrum is a continuous range of electromagnetic energy emitted as waves. These waves provide the three aspects of light which affect our perception of light: Colour or Hue, Brightness, and Saturation.

Colour or hue is determined by the length of the wave on the visible spectrum. Longer wavelengths are found towards the red end of the spectrum, whereas shorter wavelengths are located towards the blue end of the spectrum.

Brightness is determined by the highs or lows of the waves (amplitude). The lower the wave, the dimmer the light appears to be. High waves are brighter.

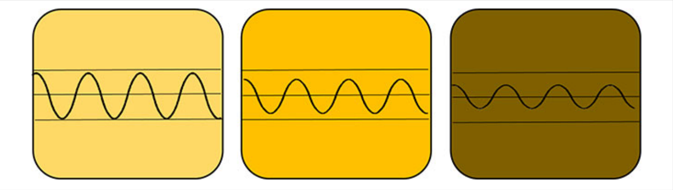

Figure 11.3.b
Source: Sruthi Sridhar

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Finally, saturation is the degree to which humans perceive colour purity. A highly saturated blue would only have blue wavelengths, whereas a less saturated blue would have a mix of wavelengths. For example, when painting a picture, if we paint the 'ocean' blue using poster colours, the paint on the paper would look 'pure' blue, but if we mix white paint to make the 'sky' blue, it will look like the lighter version of the 'blue ocean'. The hue/colour of the sky is still blue but a less saturated version of the ocean blue due to the mixture of white wavelengths.

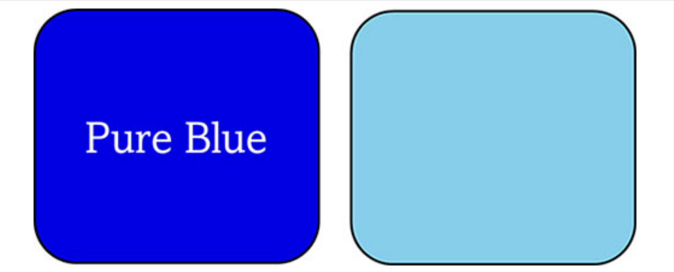

Figure 11.3.c
Source: Sruthi Sridhar

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